

CHEVRON PHOSPHATES PROJECT
ENLARGEMENT OF EXISTING TAILINGS DAM
FINAL DESIGN REPORT

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SECTION 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report presents the results of our engineering design studies for expansion of the existing tailings disposal system at Chevron Resources Company's phosphate mine near Vernal, Utah.

Existing Tailings Dam No. 2 will be enlarged to crest El. 5,970 feet by the downstream method of construction. A new dam embankment will be constructed which will extend north from Tailings Dam No. 2 around existing Tailings Dam No. 1. This construction will result in one expanded tailings dam and pond encompassing both existing Tailings Ponds Nos. 1 and 2.

The major design objectives are as follows:

- o Increase the tailings storage capacity by enlarging existing Tailings Dam No. 2 and constructing new dam embankment to crest El. 5,970 feet.
- o Provide an internal drainage system in the embankment to safely route seepage through the dam and its foundation. Seepage water will be collected downstream of the embankment and pumped back into the tailings pond or otherwise disposed of in an acceptable manner.
- o Maximize the use of locally available borrow materials and tailings sands in construction of the dam embankment.
- o Provide adequate freeboard during operation of the tailings pond to completely contain the maximum design flood without overtopping the embankment.

- o Ensure stability of the embankment under both static and seismic loading conditions.
- o Facilitate construction of the embankment and internal drainage system with construction equipment currently owned by or available to Chevron Resources Company.

The following scope of work was accomplished during the final design studies:

- o Collection, review, and evaluation of available soils, geologic, hydrologic and engineering data from previous studies and investigations of the project site.
- o Field and laboratory investigations to further define the engineering properties of the foundation soils and borrow materials.
- o Engineering design studies consisting of seepage and slope stability analyses.
- o Hydrology studies to determine the maximum flood runoff and required freeboard.
- o Preparation of final design cross-sections, layout, and details for the dam enlargement and internal drainage system.
- o Design of instrumentation and recommendations on inspection and monitoring programs.
- o Preparation of design drawings and specifications and a final design report.

Detailed design of the seepage cutoff and collection system which will be constructed downstream of the enlarged embankment was not included

in this scope of work. A conceptual layout of the system is included in the design drawings for information purposes only. Detailed design studies will be performed by others.

1.2 PROJECT LOCATION

The Chevron phosphate operation is located approximately 11 miles north of Vernal, Utah, and covers an area of about 23 square miles. It incorporates an open-pit phosphate mine, processing facilities, and tailings disposal and water supply impoundments. The project is situated on the south side of the east-west trending Uinta Mountains in the northeast corner of Utah (see Figure 1).

The predominant natural features on or near the property are Red Mountain, at about El. 7,800 feet, and Big Brush Creek Gorge, which passes near the mine. Neighboring manmade features are Steinaker Reservoir to the south, Red Fleet Reservoir to the east, and Utah State Highway 44. Chevron's property is bordered by the Ashley National Forest and by land controlled by the Bureau of Land Management (BLM). The property is located at approximately El. 5,900 feet, and Vernal is at El. 5,300 feet. The tailings ponds are sited in a tributary valley to Brush Creek, as described in Section 3.1.

1.3 PREVIOUS STUDIES

The following geotechnical investigation reports and design reports were reviewed for this work:

1. Dames & Moore, "Report of Materials Feasibility Study, Proposed Earthfill Dams near Vernal, Utah, for Stauffer Chemical Company," October 1971. This report is a study of materials available for the construction of two proposed surface-water control earthfill dikes to be located upstream and downstream of the Tailings Pond No. 2.

2. Dames & Moore, "Report of Stability Study, Existing Tailings Embankment near Vernal, Utah, for Stauffer Chemical Company," June 1972. This report presents the results of a stability study of the existing embankment dam at Tailings Pond No. 1.
3. Dames & Moore, "Report of Engineering-Design Studies, Proposed Tailings Pond No. 2 System Near Vernal, Utah, for Stauffer Chemical Company," December 1972. This report contains engineering studies and recommendations for improvement of the existing main dam at the Tailings Pond No. 2 and construction of a downstream retention dam.
4. Dames & Moore, "Geotechnical Studies and Engineering Design Report for Expansion of Tailings Pond No. 2 System Near Vernal, Utah, for Stauffer Chemical Company," December 1979. This report presents engineering studies for the enlargement of Tailings Pond No. 2 to final crest elevation of 5,900 feet.
5. International Engineering Company, Report "Volume I - Field and Laboratory Investigations, Chevron Phosphate Operations, Vernal, Utah," November 1982. This report presents the results of geotechnical investigations for the design of seepage control facilities downstream of the existing tailings ponds and for the design of a new tailings dam upstream of the existing ponds.
6. International Engineering Company, "Design Concepts for New Tailings Disposal Impoundment, Chevron Phosphate Operations, Vernal, Utah," January 1983. This letter report presents the conceptual design for a new tailings pond upstream of the existing disposal sites.
7. International Engineering Company, "Conceptual Design Studies for Expansion of Tailings Ponds No. 2, Vernal Phosphate Project, Vernal, Utah," December 1984. This report contains

the results of the geotechnical investigations and engineering analyses and design studies for the enlargement of the existing Tailings Pond No. 2.

8. International Engineering Company, "Geotechnical Investigation, Chevron Phosphate Concentrator Facility, Vernal, Utah," February 1985. This report presents the results of the field and laboratory investigations and engineering recommendations for the proposed expansion of the concentrator facility which is located north of and adjacent to the existing tailings ponds.
9. Morrison-Knudsen Engineers (formerly International Engineering Company), "Conceptual Design Studies for Expansion of Existing Tailings Pond, Chevron Phosphate Expansion Project, Vernal Utah," April 1985. This letter report presents the design concept for enlargement of the existing Tailings Ponds No. 1 and 2 by the downstream method of construction using local borrow materials and tailings sands.
10. Morrison-Knudsen Engineers, "Conceptual Design Studies for Seepage Control Below Tailings Dams, Chevron Phosphate Expansion Project, Vernal, Utah," April 1985. This letter report presents the conceptual design for seepage control facilities downstream of the existing tailings ponds.

1.4 EXISTING TAILINGS DISPOSAL FACILITIES

The existing tailings disposal facility consists of a main dam and secondary dam impounding Tailings Pond No. 2, and a main dam impounding Tailings Pond No. 1 as shown in Figure 2.

Tailings Pond No. 1 is no longer in operation; all tailings are currently deposited into pond No. 2. The current elevation of Tailings

Pond No. 2 is approximately 5,866 feet. Tailings sand is deposited from the crest of the main and secondary dams creating a tailings beach of variable width.

The crest of the main embankment for Tailings Pond No. 2 is currently being raised from El. 5,876 feet to El. 5,888 feet, and the maximum embankment height is approximately 136 feet. This embankment was constructed in 1973 to approximate El. 5,864 feet using mine-waste material consisting of gravel, cobbles and boulder-sized rock in a matrix of silty, fine to coarse sand. The upstream and downstream slopes in this material are approximately 1.3 Horizontal to 1.0 Vertical (1.3H:1V). A blanket consisting of compacted silty soil was placed over the upstream slope of the dam extending up to approximate El. 5,800 feet.

A berm consisting of compacted mine-waste material was subsequently constructed on the downstream slope of this main embankment. A graded filter zone separates the berm from both the main embankment and the underlying soil foundation. The crest of the berm is at approximate El. 5,780 feet; the width of the berm is about 60 feet. The downstream slope of the dam below the berm is approximately 1.3H:1V.

The crest of the secondary dam embankment is at approximate El. 5,880 feet and the maximum height of this embankment is about 70 feet. The embankment is constructed with dumped mine waste material as described above for the main dam. The upstream and downstream slopes of the secondary dam are both approximately 1.3H:1V. A berm consisting of compacted mine-waste material was subsequently constructed on the downstream slope of this embankment in the same manner as for the main embankment. The crest of the berm is at approximate El. 5,860 feet. The downstream slope of the dam below the berm is approximately 1.3H:1V.

These two embankments form the retaining structures for Tailings Pond No. 2 which currently covers about 100 acres and impounds about 4,400 acre-feet of tailings. These embankments are currently being raised in

three stages to El. 5,900 feet by the upstream method of construction, using compacted sand tailings from the beach. The side slopes of this enlargement are 2H:1V. The downstream slope and crests of the three stages of enlargement are covered with 2 feet of mine-waste material.

Existing Tailings Dam No. 1 is located across the small valley north of Pond No. 2. The crest elevation of Tailings Dam No. 1 varies from 5,910 to 5,930 feet and the maximum height of the embankment is approximately 140 feet. The embankment was built up in several stages. An initial 50-foot high starter dam was constructed of random rockfill materials from the mine. The remainder of the dam was raised in the upstream direction using dumped rockfill from the mine. The downstream slope of the embankment is on the order of 1.3H:1V.

Seepage emerging at the toe of the existing dams is collected in several detention ponds downstream of the dams and pumped back to the tailings ponds. In addition, a slurry wall located across the drainage downstream of the main dam intercepts the seepage flowing through the overburden soil. The impounded seepage is also pumped back to the tailings reservoir.

1.5 PROPOSED CONSTRUCTION

The proposed construction consists of (1) enlargement of the existing main and secondary embankments at Tailings Pond No. 2 from crest El. 5,900 feet to 5,970 feet in successive stages by the downstream construction method, and (2) construction of a new dam embankment encompassing the existing Tailings Dam No. 1. The plan and design cross-sections for the enlargement of the embankments are shown in Figures 2 and 5, respectively.

At a crest elevation of 5,970 feet, the dam will have a crest length of 5,600 feet and a maximum height of 254 feet. The pond will have total tailings storage capacity of 28,100 acre-ft. Of this amount, 4,400 acre-ft have already been used, and 20,500 acre-ft is available for

future tailings storage. The remaining 3,200 acre-ft of capacity is needed to provide 10 feet of freeboard. Adequate freeboard to contain the design flood will be provided throughout the life of the pond operation. The reservoir area-capacity curve is shown in Figure 1.

Because of the relatively small drainage area (5 square miles) and the low levels of precipitation in this region, no operational spillway is planned. However, a final overflow spillway will be constructed 3 feet below the ultimate dam crest elevation at one of several potential locations shown in Figure 2.

The total in-place volume of fill material needed to construct the enlargement is estimated to be about 6.6 million cubic yards. The embankment will have an upstream slope of 2H:1V and a downstream slope of 2.5H:1V. The crest width will be 30 feet. The fill material for construction of the dam will come from tailings sands, mine-waste rock, and on-site Moenkopi "red beds" siltstone and shale.

The drain system of the dam consists of inclined chimney, blanket, and collector drains and is shown in section in Figure 5. The purpose of this drainage system is to intercept seepage from the tailings pond and to route seepage through the dam and its foundation. The drain system has been sized to safely pass inflows of water from the tailings beach and foundation. Seepage will be collected and subsequently pumped back into the tailings pond.

Tailings will be transported to the tailings pond from the mill via a slurry pipeline. It is anticipated that during the years of operation, primarily slimes will be deposited into the pond. Tailings sands will be excavated from the beach and used for construction of the tailings dam expansion. Discharge of the sands will be from the crest of the dam to develop a beach on the upstream face. Slimes will be discharged into the pond away from the beach area.

A decant barge and clarified water pool will be maintained at the upstream end of the pond, and the pool will be kept as small as possible. Water will be pumped back to the mill for reuse.

A surface- and ground-water cutoff and collection system will be developed to intercept pond seepage and pump it back to the tailings pond. This system may require two or three cutoffs and collection sumps downstream of the tailings dam because of the variable topography in the project area. The system will be designed to intercept all flows through the dam and foundation as well as any leakage which surfaces downstream from underlying rock formations.

The tailings pipeline, decant barge, and surface and ground-water cutoff and collection system are not included in the scope of work for this design report.

SECTION 2

FIELD AND LABORATORY INVESTIGATIONS

2.1 GENERAL

The project site has been investigated on several occasions in relation to successive expansions of the tailings ponds and mine facilities. The results of the previous field and laboratory programs are discussed in the reports listed in Section 1.3.

The additional investigations performed during the final design phase included the following:

- o Supplemental field and laboratory investigations to better define the foundation soils.
- o Testing of Moenkopi borrow sources and additional field investigation to locate any gypsum strata which may be contained within the siltstone beds.

The detailed scope of the investigations is discussed below. Borehole and test pit locations for all exploration programs are shown in Figure 3 with reference to the exploration dates.

2.2 FIELD EXPLORATION

The current field exploration was performed during 9 April to 14 April 1985. It included drilling of eight boreholes and sampling of soils and rock. The drilling subcontractor was Erickson-Ford Company, Inc. of Boise, Idaho. The field exploration was performed under the supervision of an MKE geotechnical engineer.

The locations of the boreholes are shown in plan in Figure 3. Boreholes HA-1 through HA-6 were drilled along the foundation of the

proposed embankment in the areas not covered in sufficient detail by previous investigations. Boreholes HA-7 and HA-8 were drilled through the Moenkopi red bed siltstones in the proposed borrow area which is located along the southern edge of Tailings Pond No. 2.

The boreholes were drilled to depths ranging from 20.1 to 104.0 feet below the existing grade. A truck-mounted CME 55 rig equipped with a 7-3/4 inch hollow-stem auger was used for drilling through the soil overburden and soft rock. The boreholes were advanced through hard rock by rotary drilling with a NW core barrel.

A total of ten undisturbed soil samples were recovered from the boreholes by hydraulically pushing 2-1/2-inch O.D. Shelby-tube samplers into the soil. A total of 34 disturbed soil samples were obtained by performing Standard Penetration Tests (SPT) (ASTM D1586), which also provided blow counts useful for approximating soil strength. In addition, 35 five-foot long runs of NW rock core were obtained. The soils encountered were examined, classified, and logged by our engineer based upon the Unified Soil Classification System described in Appendix A. The rock samples were also classified and their Rock Quality Designation (RQD) values determined.

The borehole logs are presented in Appendix A. The depths at which SPT sample and undisturbed Shelby-tube samples were obtained are indicated on the logs. The SPT blow counts and RQD values are also shown on the logs. Descriptions of materials in the logs are based on visual examination made in the field. Where laboratory test data are available, the visual classifications were modified to reflect these data.

The water level in the boreholes was measured and is also shown on the logs. Fluctuations in the ground-water level are likely to occur due to changes in tailings disposal operations and variations in rainfall. The ground-water depths shown on the logs pertain only to the times of measurement.

2.3 LABORATORY TESTING

A testing program was performed on selected soil and rock samples extracted from the boreholes to establish the physical and engineering properties of these materials. All tests were performed by Rollins, Brown, and Gunnell, Inc., of Provo, Utah. Laboratory test results are presented in Appendix B.

Sieve analyses (ASTM D421 and D422) were performed for five soil samples and hydrometer tests on two of these samples to determine the particle size characteristics. Consolidation tests (ASTM D2435) were conducted on three undisturbed samples to determine the compressibility of the soils. Atterberg Limit tests (ASTM D4318) were performed on three samples to determine the plasticity characteristics.

A falling-head permeability test was conducted on one undisturbed sample. The field moisture content and dry density of seven undisturbed samples were also determined.

The shear strength of the clayey or silty soils was determined by performing unconfined compressive strength tests (ASTM D2166) on three undisturbed samples and consolidated undrained triaxial compression tests with pore pressure measurements on three undisturbed samples.

The quality of potential rock borrow materials was investigated by performing petrographic analyses of two thin sections, bulk specific gravity and absorption tests (ASTM C97) on two rock core samples, and magnesium sulphate soundness tests (ASTM C88) also on two core samples.

Permeability tests (ASTM D2434) are currently being performed on a potential borrow source for drain materials. The results of these tests will be used to confirm the permeability values assumed for design of the drain system.

SECTION 3 SITE CONDITIONS

3.1 SURFACE CONDITIONS

The tailings disposal area is located in an east-west trending valley south of the mill and concentrator facilities. The drainages, across which the three existing embankments are located, join Big Brush Creek about one-half mile downstream from the embankments and about 2,000 feet upstream of the Utah State Highway 44 bridge, which crosses Brush Creek. The drainage basin above the proposed dam has an area of 5.0 square miles and ranges in altitude from 5,850 to 7,200 feet.

Vegetation in the natural valley slopes consists of junipers, sagebrush, and a sparse growth of grass. Natural slope angles range from moderate to very steep. Rock is at or very near the surface of the hills. The soils at the lower slopes of the hills grade from rocky slope wash to alluvium in the bottoms of the gulches. Small tailings deposits and retention dikes exist at the bottom of the drainage downstream of the main dam of Tailings Pond No. 2.

The only man-made features located in the proposed dam and reservoir areas are mine facilities including access roads, pipelines, pumping stations, and a maintenance building. The latter is located at the north abutment of the proposed dam and will have to be removed prior to the construction of the last stage of the dam.

The tailings beach slopes an average of 10 percent from the crest of the main dam and the secondary dam embankments towards the tailings pond water. The surface of the tailings beach is variable in consistency and is eroded at some locations because of the peripheral tailings discharge.

3.2 SUBSURFACE CONDITIONS

A. Geology

The site is located on the south flank of the Uinta Mountain Arch near the east-central part of the range. Rocks exposed within the phosphate mine area are the Weber Sandstone of Pennsylvanian age, the Park City Formation of Permian age, and the Moenkopi Formation, which is of Triassic age. Quaternary alluvial fill is found on the valley bottom.

The Weber Sandstone is a hard, massive, fine- to medium-grained, light gray, cross-bedded quartzose sandstone that forms the high vertical cliffs along Brush Creek in the mine area. The Park City Formation, which is above the Weber Sandstone, consists of interbedded limestone, dolomite, limy sandstone, shale, and phosphatic shale. The phosphatic member at the bottom of the Park City Formation ranges from 20 to 30 feet in thickness. One of the limestone members forms the dip slope surface in the mine area.

Laying conformably on the Park City Formation is the Moenkopi Formation, which consists of thin-bedded, reddish brown siltstone or fine-grained sandstone with thin partings of weak, red, sandy shale and thin beds of light greenish gray, fine-grained sandstone. There are numerous thin veins of gypsum throughout the formation. Because the Moenkopi Formation is soft, much of it has been eroded off the upper limestone member of the Park City Formation. The Moenkopi is the only formation exposed in the study area. The contact between the Park City and the Moenkopi Formations is just to the north of the proposed embankment encompassing the existing Tailings Pond No. 1. The contact between the lower greenish gray sandstone member of the Moenkopi and the interbedded red siltstone, sandstone, and shale is generally along the drainage in which Tailings Pond No. 2 is located (Figure 3).

The structural trend of these formations is north 80 degrees east with a dip of 10 to 15 degrees southeast. No major faults were noted in the

project area. Above the Moenkopi Formation, in the hills south of the project site, are rocks of the Shinarump Conglomerate, the Chinle Formation, and the Navajo Sandstone.

B. Embankment Foundation Conditions

The proposed embankment enlargement will be founded on natural alluvial and residual soils, existing waste rock embankments, and tailings sand embankments now under construction. The detailed foundation conditions for each type of material are described in the following paragraphs. A plan of the geotechnical explorations is shown in Figure 3. Geologic profiles are shown in Figure 4.

1. Natural Soils - The following three types of foundation conditions on natural soils are encountered at the site:

- o Soils in the northernmost portion of the proposed embankment
- o Hill slopes
- o Bottom of main drainages downstream of existing dams.

a. Northernmost Portion of the Proposed Embankment - The northernmost portion of the proposed embankment is oriented in the east-west direction along the northern edge of Tailings Pond No. 1. The ground surface slopes gently toward the east. In some areas a thin layer of tailings (3-inch-thick at boring HA-1) covers the natural soils. The natural soils include loose to very dense, tan to gray brown silts with variable amounts of clay, sand, and gravel, and occasional layers of very dense silty gravel. In borehole HA-2, the silty soil contained some gypsum. The soils are dry near the dam abutment and moist at the lower elevations near the existing Dam No. 1. The depth to bedrock is about 12 to 13 feet. Bedrock consists of gray Moenkopi siltstone. The rock is heavily fractured and weathered with gypsum lenses of up to 1/4 inch in thickness. Rock weathering decreases with depth. At the time of measurement, the ground-water depth was determined to be 28.2 feet at borehole HA-2. Ground-water was not encountered at borehole HA-1.

b. Hill Slopes - The hill slides are covered with a thin mantle of residual soil consisting primarily of loose to dense, dry to moist, silt. The soil color varies with the color of the underlying bedrock, that is, greenish gray to light brown at the northern portion of the site and red to reddish brown to the south. Soil thickness ranges from zero to five feet. The silt contains occasional fine gravel and grades to very weathered and fractured, interbedded siltstone and sandstone bedrock. The rock is gray, red, and reddish brown, soft to medium hard, and contains many lenses and hairline seams of gypsum. Weathering decreases with depth.

c. Drainages - The natural soils filling the bottom of the drainage downstream of Dam No. 1 consist of alluvial gray and gray brown clayey silt with depths to bedrock ranging from 10 to 25 feet. The upper 9 inches of soil contain abundant organic material. The soil is soft near the surface and becomes stiffer with depth. At the time of measurement, the ground-water depth was determined to be 22 feet at borehole HA-3 and 8 feet at borehole MW-3. Approximately 600 feet downstream of the dam, a small dike impounds the seepage water which emerges at the toe of the dam.

The bottom of the drainage across which the secondary dam of Tailings Pond No. 2 is located appears to be covered with a thin layer of alluvial soil. Seismic lines SL-7 and SL-8 indicate overburden depths of zero to eight feet. At monitoring well MW-2, which is located at the east end of the drainage, the soil consists of brown sandy and gravelly silt and silty sandy gravels. The soil is loose at the surface and becomes denser with depth. Sandstone and siltstone bedrock was encountered at a depth of 20 feet. At the time of measurement, the ground-water depth was observed to be 12 feet below the ground surface.

The bottom of the drainage downstream of the main dam is filled with alluvium and rocky slope wash from the soft, red Moenkopi Formation. Typically the soil consists of reddish brown, loose, sandy clayey silt to depths ranging from 9 to 20 feet below the natural surface. At the

toe of the dam, this silt stratum is underlain by gray and reddish brown, fine to coarse sand and gravel with occasional cobbles and trace of silt. This material is loose to medium dense and extends to a depth of between 43 and 50 feet below the existing ground surface. The sands and gravels are bedded with lenses of sandy silt and some clay. Bedrock consisting of reddish brown soft siltstone and fine-grained sandstone was encountered below the sand and gravel stratum. The rock is highly fractured and weathered and contains numerous thin white gypsum veins subparallel to the bedding. The rock becomes moderately hard and less weathered with depth.

Approximately 400 feet downstream of the toe of the main dam is a 12- to 15-foot-high seepage retention dike constructed with silty gravel and rockfill. The dike is founded on a 13-foot-thick layer of reddish brown, loose silt. The underlying material consists of brown to reddish brown, medium dense to dense, gravelly sandy silt. Bedrock was found at a depth of 50 feet below the crest of the dike, or 35 feet below the original ground surface.

The ultimate toe of the proposed embankment enlargement will reach approximately 200 feet downstream from the existing seepage retention dike. The log of monitoring well MW-1, located in that area, indicates that the upper 20 feet of the soil consists of alluvial, red, sandy clayey silt. This soil is loose, nonplastic, moist, and contains a little fine gravel. A 23-foot-thick layer of reddish brown, loose, sandy gravel was encountered under the silty soil. This material overlies sandstone and siltstone bedrock. The rock is reddish brown to dark brown, fine grained, soft, and highly weathered and fractured. It contains numerous thin white gypsum veins up to 1/8-inch in thickness.

An old slimes pond is located downstream of the ultimate dam toe line (Figure 3). The slimes consist of light greenish brown, very soft, highly plastic clay. This soil is slightly organic, with traces of lignite and plant fibers. In some areas it is covered with a 2- to 2.5-foot-thick layer of reddish brown, nonplastic to slightly plastic sandy clayey silt with abundant organic material.

The ground-water table in the drainage fill is fed by seepage from the main dam and from the retention pond. As a result, at the bottom of the drainage, the water table is generally only a few feet below the ground surface.

2. Existing Waste Rock Embankments - A portion of the upstream slope of the proposed enlargement will be founded on the downstream slopes of existing waste rock embankments. These embankments were constructed with stripped overburden materials from the mine area. The material forming Dam No. 1 consists of medium dense to dense, gray to light brown, silty fine to coarse sand and gravel with occasional cobbles and boulders.

The soils in the main and secondary dams of Tailings Pond No. 2 are a mixture of light grayish-brown, fine to coarse gravels, cobbles, and boulder-sized rock in a matrix of silty fine to coarse sand. The material ranges from loose to medium-dense and contains large zones where segregation of sizes has occurred. Stabilizing rockfill buttresses were constructed on the downstream slopes of the dams using selected mine waste material, as described in Section 1.4. Filter zones consisting of sand tailings were placed between the embankments and the buttresses. The buttress materials were placed in compacted lifts.

3. Tailings Sand Embankments - As indicated in Section 1.4, Tailings Pond No. 2 is now being raised by means of tailings sand embankments constructed by the upstream method. The upstream toe of the proposed enlargement will be founded on the downstream slope of the compacted sand embankments, which in turn are founded on the sand beach of the tailings reservoir. The soil conditions at the sand beach and compacted sand embankments are discussed below.

Previous investigations indicate that the tailings beach consists predominantly of tailings sand to depths on the order of 50 to 60 feet below the surface of the beach. Slime layers were encountered,

however, at depths as shallow as 13 feet below the surface. The tailings sand is very loose to loose, medium- to fine-grained, and contains variable amounts of silts. The slime layers are as thick as five feet and consist of silt and clay with low to moderate plasticity. The layers are soft to medium stiff.

Below a depth of approximately 50 to 60 feet the materials encountered were predominantly slime tailings. The slimes are normally-consolidated to under-consolidated silt and clay of low to moderate plasticity and are very soft to stiff.

At the compacted tailings sand embankments now under construction, the sand fill is being placed by the upstream construction method in horizontal lifts. The sand is obtained from the tailings beach, and it is our understanding that the sand is compacted to at least 90 percent of maximum dry density as determined by ASTM Test Method D1557-78. In addition, the downstream slope of the completed sand fill is covered with a minimum of two feet of end-dumped mine waste material.

3.3 SEISMICITY

Earthquakes in Utah occur primarily within a 60- to 100-mile wide zone of the Southern Intermountain seismic belt that marks the transition between the Basin and Range province and the Colorado Plateau and Middle Rocky Mountain provinces. This earthquake zone trends north-south from the Utah-Idaho border to the area around Richfield and then changes to a southwest trend that extends across the Utah-Nevada border. The eastern edge of this seismic belt extends into the Uinta Basin about as far as Duchesne. The project area near Vernal is approximately 80 miles east of the main seismic belt. There have been low magnitude earthquakes reported northeast of Vernal, but all were measured at less than 4.0 on the Richter scale.

The project area falls in Seismic Zone I and has the potential for very low seismic activity, as indicated in both the Uniform Building Code and the Rules and Regulations Governing Dam Safety in Utah (Ref. 1 and 2). No major faults were seen in the project area during previous geologic reconnaissances.

The U.S. Corps of Engineers' recommended guidelines for safety inspection of dams (Ref. 3), indicates that the seismic coefficient for use in pseudo-static slope stability analyses should be 0.025 for projects located in the Seismic Zone 1. Therefore, this value was used in the stability analyses described in Section 4.2.

SECTION 4 ENGINEERING DESIGN STUDIES

4.1 HYDROLOGY AND FREEBOARD REQUIREMENTS

Because sufficient freeboard will be constantly maintained to fully contain run-off resulting from the probable maximum precipitation event, no operational spillway is planned for the construction period (approximately 20 years). However, for added safety, a final overflow spillway will be constructed 3 feet below the ultimate crest elevation of 5970 at one of several potential locations as shown in Figure 2. Final design of the overflow spillway will be accomplished at a later date. Flood routing analyses are not planned because adequate freeboard is to be provided to contain a probable maximum flood event without spilling. An area-capacity curve for the reservoir has been developed and is included in Figure 1.

The drainage area above the enlarged embankment was calculated to be 5.0 square miles. Following procedures outlined in Reference 4, the 24-hour probable maximum precipitation (PMP) event was estimated to be 9.45 inches. The surface soils in the project area were estimated to classify within Soil Conservation Service (SCS) hydrologic soil group C. This group is described as soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. The grass and brush coverage of the watershed area was estimated as poor to fair. For antecedent moisture condition III, the runoff curve number was estimated to be 91 (Reference 4). Using the estimated PMP and curve number, direct runoff was calculated to be 8.5 inches. Total runoff from the drainage area was calculated to be 2,300 acre-feet.

At the proposed final overflow spillway crest elevation of 5967 feet, the pond will have a total storage capacity of 27,200 acre-feet. Of

this amount, 4,400 acre-feet have already been used for tailings storage, and 20,500 acre-feet is available for future storage of tailings. The remaining 2,300 acre-feet of capacity is needed to provide 7 feet of freeboard below the spillway crest in order to retain the runoff from the PMP without spilling. During construction (i.e., life of the pond operation), a minimum freeboard of 10 feet below the embankment crest will be maintained which will be adequate to retain the full PMP runoff without overtopping.

4.2 STABILITY ANALYSES

Slope stability studies were performed on two design cross-sections of the final enlarged embankment. Cross-sections C and F (shown in Figure 5) were selected for the analyses because these sections were judged to be the most critical from a stability standpoint due to their large heights and steeper slopes and the presence of relatively deep alluvial foundation soils. All other design cross-sections are expected to have higher factors of safety than those calculated in this study.

The material properties used in the stability analyses are presented in Table 1. The strength parameters for the natural foundation soils, slime tailings, and mine waste rock were based on our field and laboratory work and on the previous work by others (Section 1.3). The strength parameters in the tailings beach and zone of layered sand and slimes were based on published correlations with Standard Penetration blowcounts. The strength parameters for the compacted tailings sand were based on results of triaxial testing performed by MKE during a previous study.

TABLE 1
MATERIAL PROPERTIES FOR STABILITY ANALYSES

No.	Material Description	Friction Angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
1	Existing Mine Waste Rock	40	0	130
2	Compacted Tailings Sand	33	0	125
3	Random Fill - Compacted Tailings Sand and Moen- kopi Siltstone	28	200	125
4	Tailings (Mainly Slimes)	7.5	560	100
5	Tailings Sand and Slimes	28	0	120
6	Foundation Soil	30	0	120
7	Bedrock	45	10,000	145

The random fill material for construction of the dam will come from both tailings sand, mine-waste rock, and on-site Moenkopi formation. Strength parameters selected for the random fill zone are based on past experience and information from published literature (Ref. 5). In our selection we have conservatively assumed that the Moenkopi will break down into predominantly silt and clay size particles. Therefore, the strength parameters chosen for the random fill zone are relatively low and can be considered to be representative of a "worst-case" situation.

The analyses were accomplished using the computer program SLOPE which computes the factors of safety for specified slip circles by the Simplified Bishop Method. A seismic coefficient of 0.025 was used for the pseudo-static analyses.

The results of the analyses are shown graphically in Figures 9 and 10. For cross-section C, the minimum steady seepage and pseudo-static (seismic) safety factors are 1.53 and 1.41, respectively. For cross-section E, the minimum safety factors for these two cases are 1.55 and 1.44, respectively. These factors of safety are more than adequate and satisfy the Utah State Engineer's recommended criteria for slope stability (Reference 2).

4.3 INTERNAL DRAINAGE SYSTEM DESIGN

A. Description

The purpose of the internal drainage system is to intercept seepage from the tailings pond and to route the seepage safely through the dam and its foundation. The drains have been designed with ample capacity to convey the maximum seepage inflows from the tailings beach and foundation.

The proposed drainage system consists of a chimney drain, blanket drains, and collector drains. The plan location of blanket and collector drains is shown in Figure 6. The location of the chimney drain is shown in the embankment cross-sections of Figure 5, and miscellaneous drain details are presented in Figure 7. Each element of the drainage system is briefly described below.

The position of the chimney drain within the embankment varies along the embankment alignment (Figure 5). In the area where the embankment will be raised above the crest of the existing embankments or above the access road to the pond (cross-sections B, C, and D of Figure 5), the chimney drain will be brought up from the existing crest or access road, first vertically and then parallel to the upstream slope of the dam. In the remaining areas, the chimney drain will be brought up parallel to the upstream slope of the dam (cross-sections A, E, and F of Figure 5).

The chimney drain will discharge the seepage flow into collector drains running along its toe except where the embankment is built on the downstream slopes of the existing embankments. In these areas, the chimney drain will be tied to blanket drains covering the slopes, as shown by the shaded areas in Figure 6, and collector drains will be located at the downstream edge of the blanket drains.

The collector drains will transport the seepage flow across the dam foundation to the downstream toe of the embankment. Because collector

drains have to convey concentrated flows along relatively gentle slopes, they will be provided with a core of very coarse, highly pervious, gravel material. The required core material gradation band is described in the Specifications.

A filter layer of compacted tailings sand will be provided between the blanket drains and the downstream slopes of the existing embankments in order to prevent piping of pond slimes through the embankment rockfill and into the drain material (Figure 7, details 1, 3, 4, and 6).

Likewise, two filter layers are required to separate the natural silty soils from the coarse-grained material in the collector drain cores (Figure 7, details 4 through 7). The outer filter layer will consist of compacted tailings sand, and the inner filter layer will consist of gravelly sand blanket-drain material. At the surfaces where the collector drains are in contact with embankment material (compacted sand tailings or rockfill) only the inner filter layer will be needed.

B. Design Methodology

The drains were designed to safely convey the maximum seepage flow through the embankment and dam foundation. The seepage flow was determined from the final maximum pond elevation 5960 feet by means of conventional flow net calculations. The maximum seepage quantity entering the drain system was calculated on the assumption that, during operations, a tailings sand beach at least 200 feet wide will be maintained between the embankment and the pool of free water. Average tailings beach permeability was estimated to be no greater than 5×10^{-4} centimeters per second on the basis of results of laboratory permeability tests performed by others. In addition, the assumption was made that operation of seepage collection systems downstream of the dam will not submerge the drains.

The maximum seepage flow rates collected at the toe of the embankment were estimated to be as follows:

<u>Collection Area</u>	<u>Flow (gpm)</u>
Northern Drainage Downstream of Tailings Dam No. 1	650
Middle Drainage Downstream of Secondary Dam	300
Southern Drainage Downstream of Main Dam	1,000

The capacities of the chimney drains, blanket drains, and collector drains were calculated by applying Darcy's Law. The minimum coefficient of permeability for the chimney and blanket drain material was estimated to be 0.1 centimeters per second for the specified gradation band. For the drain core material, the minimum coefficient of permeability was estimated to be 35 centimeters per second. The capacities of the collector drains were calculated on the basis of the minimum drain slopes specified in Figure 7.

The required drain cross sections were estimated using safety factors ranging from 5 to 10 to account for possible reductions in drain capacity due to turbulent flow effects and to minor localized changes in material gradations.

4.4 SITE PREPARATION

Site preparation should extend over the entire area to be covered by embankment fill or drain material and should consist of clearing, stripping, excavation, and foundation preparation, as discussed below.

All embankment subgrade areas should be kept well graded and drained; ponding of seepage water or storm runoff should not be allowed. All junipers, sage brush and other vegetation (including roots) should be cleared from all areas to be covered with fill or drain material. Grass, roots, and other deleterious materials should be stripped and disposed of in an acceptable manner. Stripped materials must not be used as fill in the embankment or drains. The depth of stripping should be determined in the field by a qualified engineer. Anticipated depths are 0 to 12 inches depending on the density of vegetation for

all embankment foundation areas except the bottom of the northern and southern drainages.

More extensive foundation work will be required in the northern and southern drainages which contain the existing seepage collection ponds and are filled with soft, saturated alluvial soils. Prior to starting foundation preparation in these areas, it will be necessary to construct new seepage collection ponds downstream of the existing collection ponds. Design of these ponds was not included in this scope of work and will be performed by others. For illustrative purposes only, the conceptual layout of these ponds has been included in Figure 6.

After the new collection ponds are completed, the dikes forming the existing collection ponds should be removed and the ponds drained into the new ponds. In order to facilitate drainage, it may be necessary to excavate drainage trenches through the alluvial soils from the existing to the new collection ponds.

Once the existing ponds have been drained and have dried out sufficiently to allow access to earthmoving equipment, the very soft soils, deleterious materials and vegetation in the bottom of the drainage should be removed. If some areas remain too soft to allow access, a rock pad can be built by bulldozing mine waste rock or Moenkopi siltstone onto these areas. The depth of soft soils to be removed from the bottom of the drainages should be determined in the field by a qualified engineer. A rough estimate of the maximum depths of excavation is 10 to 15 feet in the northern drainage and 7 to 10 feet in the southern drainage. However, greater excavation depths may be required in localized areas.

After the drainages have been cleared of all unacceptably soft soils and deleterious materials, they should be brought up to the grades shown on Figure 6 with compacted fill. Moenkopi siltstone may be used as fill in this area; however, at least 4 feet immediately below the drain foundation should consist of mine-waste rock or sand tailings.

After stripping and excavating as required but prior to placing any fill or drain material, the exposed ground surface should be compacted as required by the Specifications to ensure adequate foundation strength.

Where embankment or drain materials will be placed on the existing embankments, only minor foundation preparation will be required. Large, open-graded, boulders greater than 18-inches should be removed from the existing embankments prior to placing compacted sand tailings. The boulders may be stock-piled for later use in the random fill embankment Zone 4 (Figure 5).

4.5 EMBANKMENT CONSTRUCTION MATERIALS

The embankment and drain system will be constructed with four different material types. Material descriptions and sources for each material type are discussed below.

A. Material Type 1

Material Type 1 will be used for the chimney and blanket drains and as a filter for the collector drains. This material should consist of durable gravelly sand and must be free of organics, oversized rocks and other deleterious materials. Gradation requirements for this material are given in the Specifications. These gradation requirements were developed using established filter criteria (Ref. 4). These criteria ensure that the material will be sufficiently fine to prevent piping of sand tailings into the drains but also sufficiently coarse so as to have a high enough permeability to function as an adequate drain. In addition, this material satisfies the filter criteria with respect to Material Type 2.

No material or blend of materials presently available at the site meets the gradation requirements for Material Type 1. Therefore, this drain material will be obtained from an off-site borrow source.

B. Material Type 2

Material Type 2, which will be used in the collector drains, consists of coarse gravels. The material should be durable and must be free of organics, oversized rocks and other deleterious materials. Gradation requirements for this material are given in the Specifications. The material as specified will be coarse enough to provide free drainage and also will satisfy filter criteria with respect to Material Type 1.

As for Material Type 1, no material or blend of materials presently available at the site will meet the gradation requirements for Material Type 2. Off-site commercial borrow sources are currently being investigated.

C. Material Type 3

Material Type 3 consists of compacted tailings sand produced as a waste product of the phosphate mill process. As described in Section 3, this material generally is fine grained sand with between 5 and 27 percent by weight finer than the No. 200 sieve. Sand tailings will be used for embankment construction in the zone upstream of the chimney drains and also will be placed as a filter below the blanket drains and collector drains.

The tailings sands are transported from the mill to the tailings pond via a slurry pipeline. The tailings are deposited into the pond from the embankment crest forming a tailings beach of variable width (approximately 200 to 500 feet). Tailings sand will be excavated from the beach and used for construction of the dam expansion.

A revision in the mill process is planned which will alter the gradation of the sand tailings. The exact revised gradation for the tailings is not known at this time. Since the required gradation of Material Type 1 has been developed to satisfy filter criteria with respect to the sand tailings, it may be necessary to revise the

gradation requirements for Material Type 1 after the revision in the mill process has been accomplished.

D. Material Type 4

Material Type 4 is a random fill consisting of sand tailings, mine-waste rock, or Moenkopi siltstone and shale. This material should be used only downstream of the internal drainage system where the material will be isolated from pond seepage water. This material can also be used to fill the northern and southern drainages below the collector drains. As discussed in Section 4, however, only mine waste rock or sand tailings should be placed in the upper 4 feet of fill in those drainages below the collector drains.

The sand tailings have been described in paragraph C, above. The mine waste rock consists of predominantly hard limestone overburden materials from the phosphate mining operation. This material was used to construct the existing main and secondary dams of Tailings Pond No. 2 and Dam No. 1. Past experience indicates that the mine-waste rock will break down during transportation and compaction into fine to coarse gravel, cobbles, and boulders in a matrix of silty fine to coarse sand.

Since sufficient sand tailings will not be available in the quantities required for construction of the embankment enlargement, Moenkopi siltstone and shale and mine waste rock will also be used for Material Type 4. The potential borrow sources for the Moenkopi are located within the reservoir area as shown in Figure 2. Our field investigation found that in the borrow areas the Moenkopi consists generally of medium hard siltstone and sandstone with very thin lenses of gypsum. The overall gypsum content is estimated to be quite low, although a 2- to 8-foot-thick layer of intermixed gypsum and siltstone was found at approximately 26 foot depth. During excavation in the borrow areas, it will be necessary to reject any Moenkopi containing a significant proportion of gypsum.

Previous seismic surveys in the vicinity of the borrow areas found that the seismic velocity of the Moenkopi can be as high as 12,500 feet per second indicating that blasting may be required for excavation.

SECTION 5 INSTRUMENTATION AND MONITORING

5.1 GENERAL

As the tailings dam is being enlarged it is important to monitor its performance to ensure that the structure is functioning as designed. Additionally, it is important to monitor long term performance following completion of the project. A properly designed monitoring system will facilitate timely changes during operations, and may justify cost saving adjustments in later years. This monitoring system requires a carefully planned instrumentation installation and operation program to measure pore water pressures, settlements, movements and other key "vital signs." The instrumentation system planned for the tailings dam consists of stand-pipe piezometers, displacement markers and weirs as described below.

5.2 PIEZOMETERS

In order to monitor the performance of the internal drainage system, three stand-pipe piezometers will be installed at the locations and elevations shown in Figure 8 when the dam crest reaches elevation 5900 feet. As the embankment is enlarged, the outer protective metal pipe and PVC pipe will be extended in stages. Care will have to be exercised to protect the piezometers as much as possible during the placement of embankment fill, and damaged or malfunctioning piezometers should be replaced.

Immediately after installation, each piezometer should be tested and the water elevation should be read and recorded. Thereafter, we recommend that the water surface elevation in the piezometers be measured and recorded at least each month. More frequent measurements should be made if anomolous readings or sudden changes in readings

occur which might signal the possibility of an internal drainage problem in the embankment.

5.3 DISPLACEMENT MARKERS

Because the dam embankment will be raised in successive stages, the crest alignment will vary accordingly. As the dam is enlarged, a system of displacement markers will be established both along the crest of the dam and on the downstream slope of the embankment. The markers will be located as follows:

- o One displacement marker per 100 feet along the crest line.
- o One displacement marker per 100,000 square feet of downstream dam surface.

As new embankment fill is placed, the markers will be removed and replaced. The system will be correlated with established reference points consisting of on-site bench marks outside of the final embankment downstream toe line.

Elevations and coordinates of measurement points should be read immediately after the markers are established. At other times measurement points should be read either monthly or more often if required.

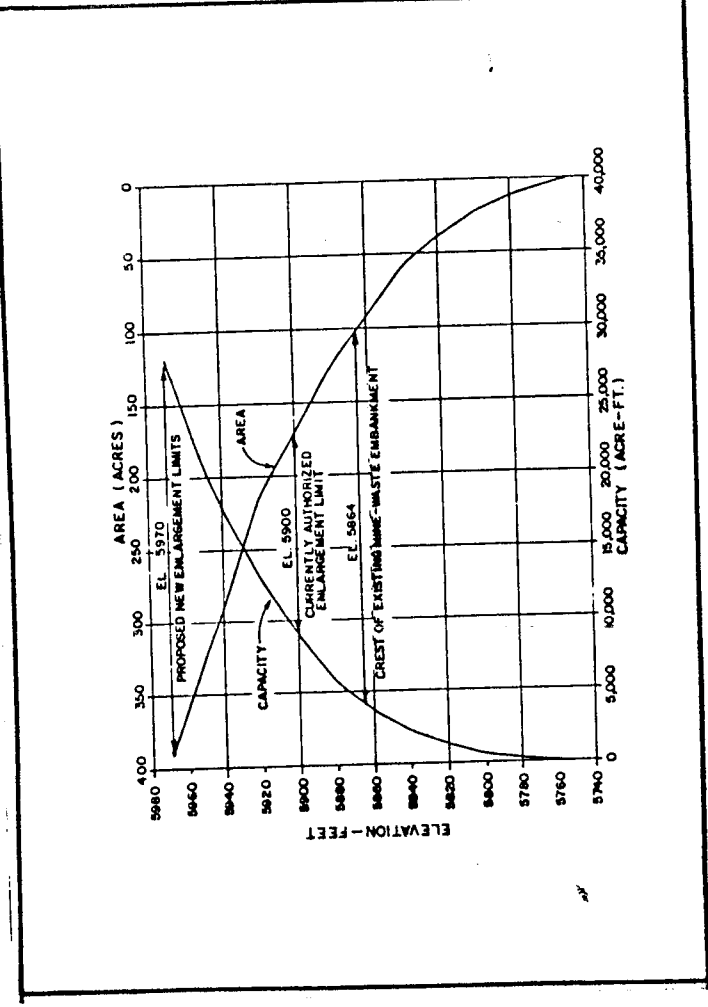
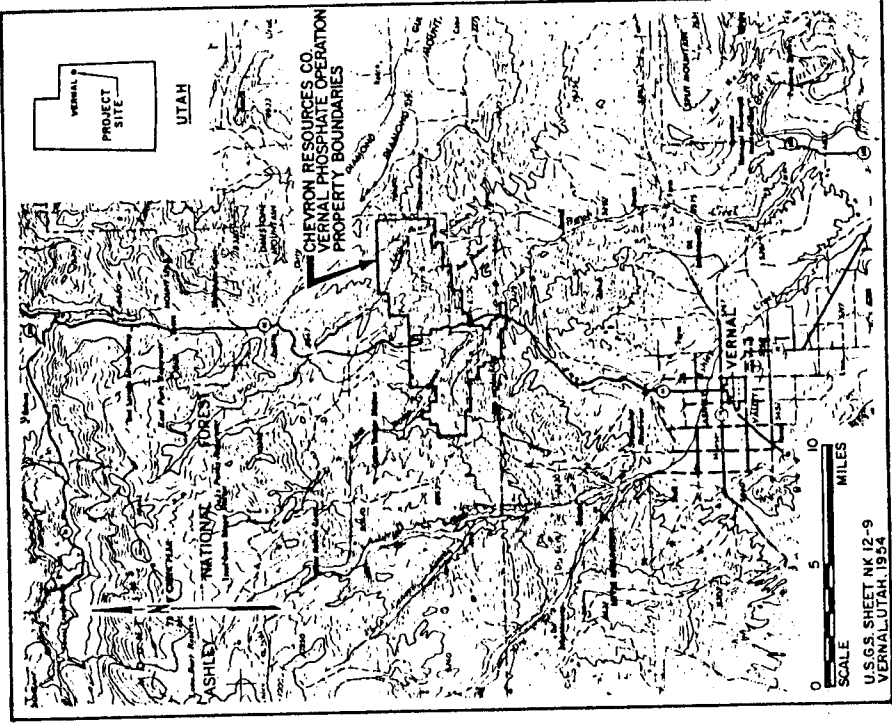
5.4 SEEPAGE MEASURING WEIRS

In order to measure seepage flow rates through the internal drainage system, seepage measuring V-notch weirs will be constructed downstream of the embankment at the approximate locations shown on Figure 8. The exact location of the weirs will be determined in the field.

A schematic diagram of the weir is shown in Figure 8 along with the corresponding weir rating curve. We recommend that flow rates be measured and recorded every week, although measurements should be made more often if sudden changes in seepage flow are observed.

SECTION 6
REFERENCES

1. International Conference of Building Officials, Uniform Building Code, 1982.
2. Utah State Division of Water Rights, "Rules and Regulations Governing Dam Safety in Utah," January, 1982.
3. U.S. Army Corps of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D," 1977.
4. U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1977.
5. Federal Highway Administration, "Design and Construction of Compacted Shale Embankments, Vol. 1, Survey of Problem Areas and Current Practices," Report No. FHWA-RD-75-61, August 1975.



DRAWING INDEX	
FIGURE	SUBJECT
1	COVER SHEET, PROJECT LOCATION & AREA-CAPACITY CURVE
2	TOPOGRAPHY, SURVEY DATA & EMBANKMENT LAYOUT
3	GEOLOGIC PLAN
4	GEOLOGIC PROFILES
5	DAM CROSS-SECTIONS
6	DRAINAGE SYSTEM PLAN AND PROFILE
7	MISCELLANEOUS DETAILS
8	INSTRUMENTATION PLAN AND PROFILE

CHEVRON RESOURCES COMPANY

APPROVED AND ACCEPTED THIS 9th DAY
OF August 1985.

Thomas M. Carlson

ENGINEER

CERTIFICATE OF ENGINEER

I DO HEREBY CERTIFY THAT THESE PLANS FOR THE
CONSTRUCTION OF THE VERNAL PHOSPHATE TAILINGS DAM
WERE PREPARED BY ME FOR THE OWNERS THEREOF.

E. S. Smith
9 Aug. '85
DATE

PROFESSIONAL LICENSE NO. 4719 UTAH

CERTIFICATE OF ACCEPTANCE

CHEVRON RESOURCES COMPANY CERTIFIES THAT
IT HAS EMPLOYED MORRISON-KNUDSEN ENGINEERS,
INC., FORMERLY INTERNATIONAL ENGINEERING
CO., INC., TO PREPARE THE ACCOMPANYING DRAWINGS
AND SPECIFICATIONS FOR THE CONSTRUCTION OF THE
VERNAL PHOSPHATE TAILINGS DAM AND THAT IT ACCEPTS
THESE DRAWINGS AND SPECIFICATIONS.

Thomas M. Carlson

STATE ENGINEER

STATE ENGINEERS APPROVAL

IN ACCORDANCE WITH SECTION 73-5-5 UTAH CODE
ANNOTATED 1953, AS AMENDED, APPROVAL IS HEREBY GIVEN
FOR THE CONSTRUCTION OF THE VERNAL PHOSPHATE TAILINGS
DAM.

INTERNATIONAL ENGINEERING COMPANY, INC.

90 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED JDL DRAWN RBC CHECKED PKC RECOMMENDED PKC
DATE APRIL 1985 APPROVED PMG

NO.	DATE	REVISIONS
1	5-14-85	ISSUED FOR APPROVAL
0	4-30-85	ISSUED FOR REVIEW AND COMMENT

CEB PKC	PMG
JDL PKC	PMG
BY CHK	APPD

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

COVER SHEET, PROJECT LOCATION
& AREA-CAPACITY CURVE

ECO NO.	2151D - DG1
SHEET	1
OF	8
REV.	1
FIGURE	1



LEGEND:

- +DH-1 DRILL HOLES DH-1 THRU DH-9, IECO, FEB. 1985
- 1- DRILL HOLES 1, 2 & 3, D & M, JUNE 1972
- TP-1 TEST PITS TP-1 THRU TP-5 & TP-8 THRU TP-12, D & M, DEC. 1972
- 1- DRILL HOLES 1, 1A, 2 & 3, D & M, DEC. 1972
- R-1 DRILL HOLES R-1 THRU R-6, D & M, DEC. 1979
- TP-1 TEST PITS TP-1 THRU TP-5, IECO, NOV. 1982
- MW-1 MONITORING WELLS MW-1 THRU MW-3 & MW-6, IECO, NOV. 1982
- OW-1 OBSERVATION WELLS OW-1 & OW-3, IECO, NOV. 1982
- A-1 HAND AUGER HOLES A-1, A-2, A-3, B-1, C-1, D-1 & D-2, IECO, NOV. 1982
- SL-1 SEISMIC LINES SL-1 THRU SL-10, IECO, NOV. 1982
- D-1 DRILL HOLES D-1 THRU D-6, IECO, NOV. 1982
- CP-1 DRILL HOLES CP-1 THRU CP-9, IECO, DEC. 1984
- HA-1 DRILL HOLES HA-1 THRU HA-8, IECO, APRIL 1985
- WW-E WATER WELL, CHEVRON, 1981
- 26 DIP & STRIKE OF BEDS (DEGREES), IECO, NOV. 1982
- 85 DIP & STRIKE OF JOINTS (DEGREES), IECO, NOV. 1982
- N50W VERTICAL JOINT, IECO, NOV. 1982

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
80 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

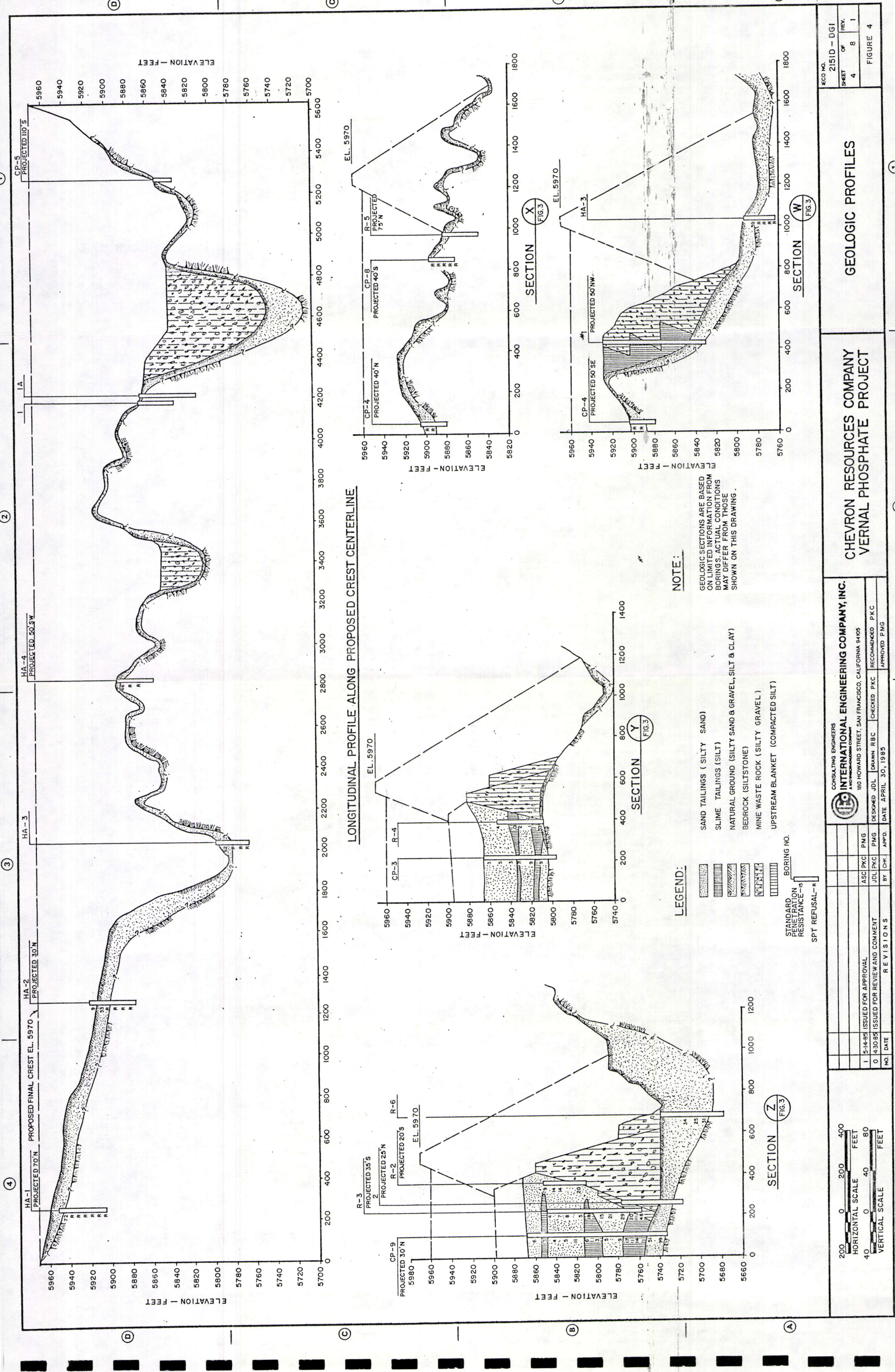
NO.	DATE	BY	CHK	APPD.	DATE	APPROVED	PKC
1	5-14-85	JDL	PMC	CEB	PMC	ISSUED FOR APPROVAL	RECOMMENDED
2	4-30-85	JDL	PMC	JDL	PMC	ISSUED FOR REVIEW AND COMMENT	APPROVED

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

GEOLOGIC PLAN

ECO NO.	2151D - DG1
SHEET	3
OF	8
REV.	1
FIGURE	3





2000

0

200

400

HORIZONTAL SCALE

FEET

40

0

40

80

VERTICAL SCALE

FEET

NO.

DATE

REVISIONS

BY

CHK.

APPD.

PMG

ASC

PKC

PMG

1

5-14-85

ISSUED FOR APPROVAL

JDL

PKC

PMG

0

4-30-85

ISSUED FOR REVIEW AND COMMENT

JDL

PKC

PMG

CONSULTING ENGINEERS

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190 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

A SUBSIDIARY OF THE INTERNATIONAL ENGINEERING COMPANY

DESIGNED JDL DRAWN RBC CHECKED PKC RECOMMENDED PKC

DATE APRIL 30, 1985

APPROVED PMG

CHEVRON RESOURCES COMPANY

VERNAL PHOSPHATE PROJECT

ECO NO.

2151D-DGI

SHEET OF

4 8

REV.

1

FIGURE

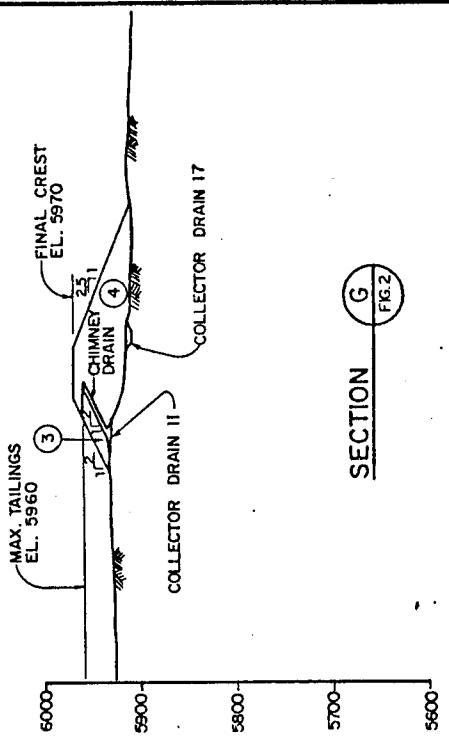
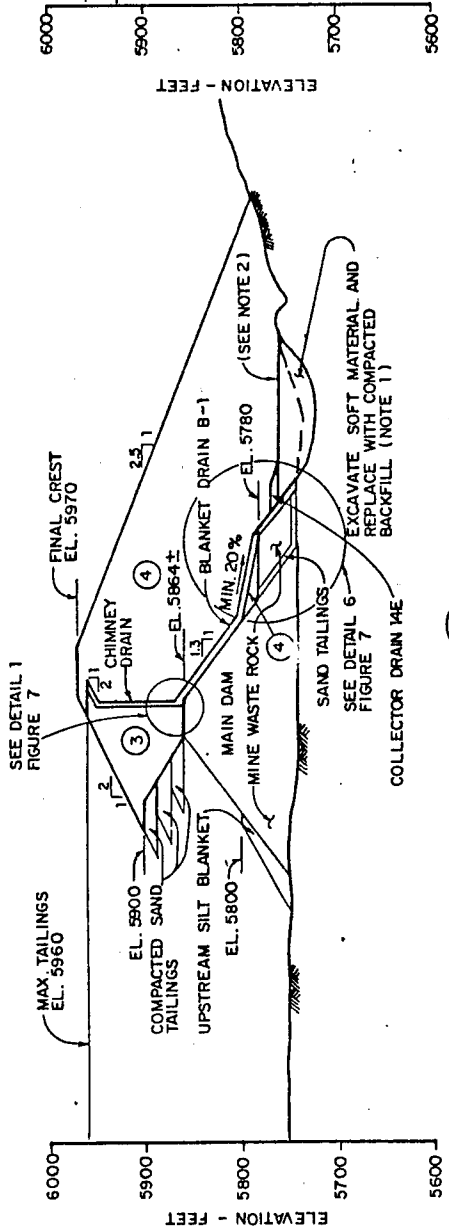
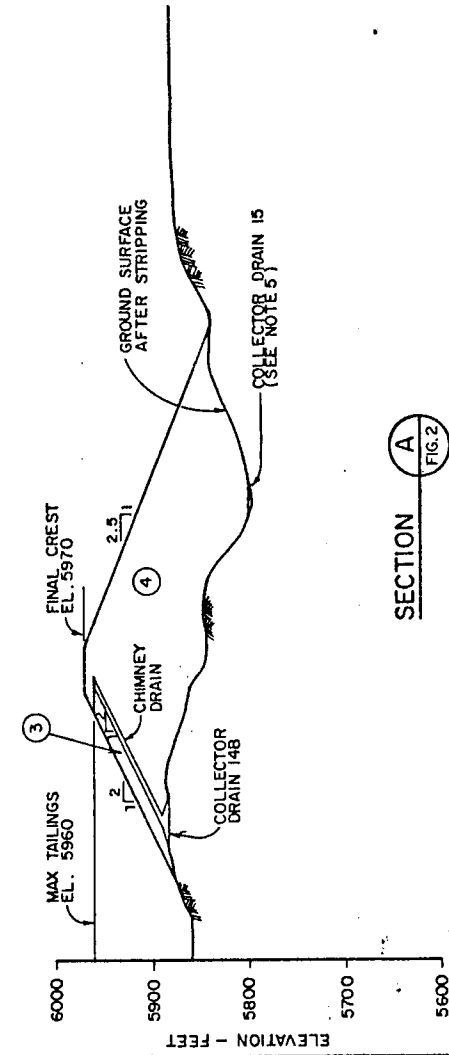
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1

2

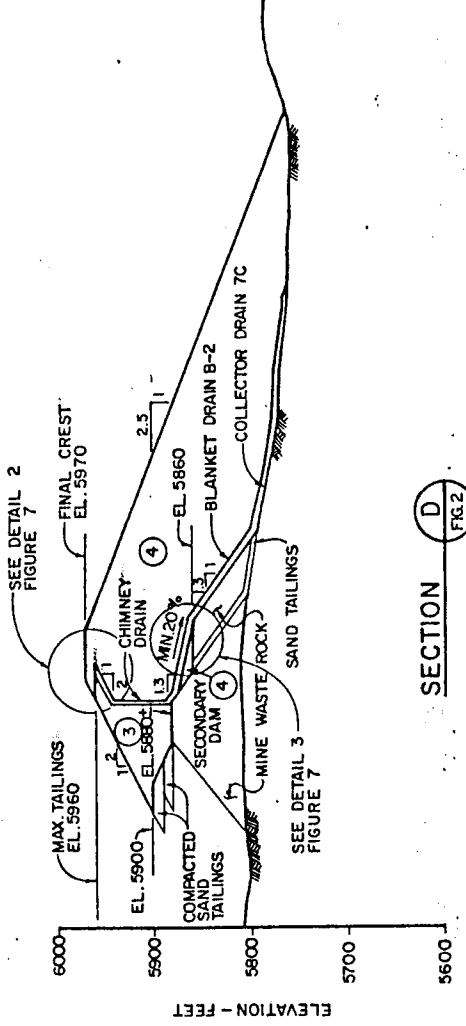
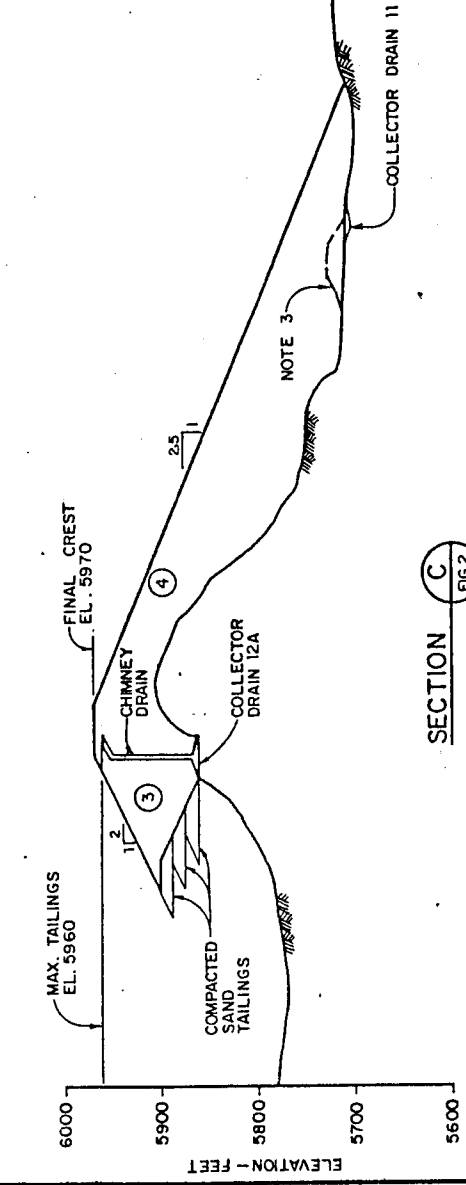
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4



NOTES:

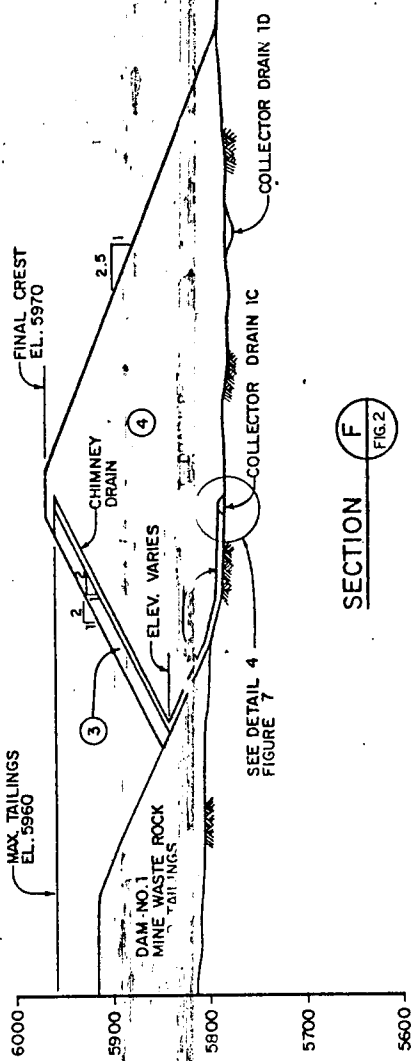
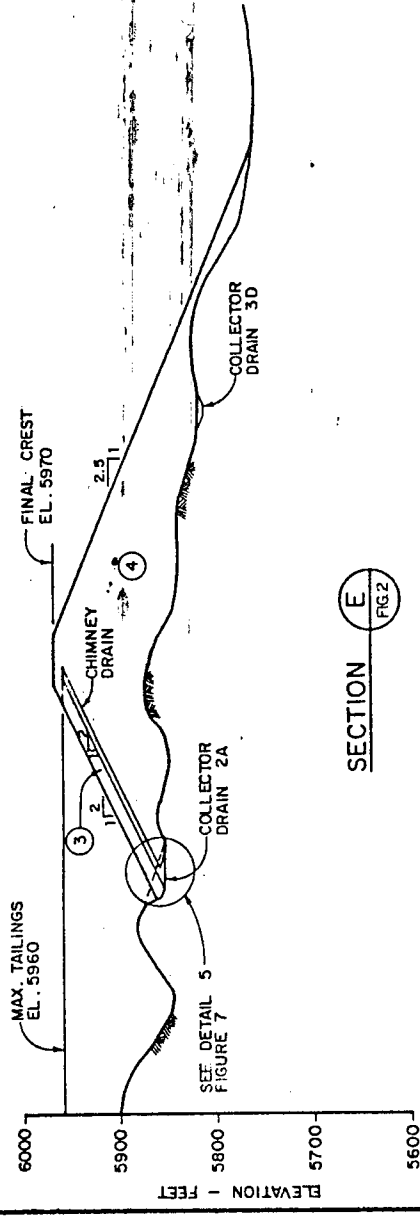
1. DEPTH OF EXCAVATION SHALL BE DETERMINED IN THE FIELD.
2. PLACE COMPACTED FILL TO GRADE AS SHOWN IN FIGURE 6.
3. REMOVE EXISTING DIKES AND DRAIN EXISTING SEEPAGE COLLECTION PONDS PRIOR TO PLACEMENT OF FILL.
4. SEE FIGURE 7 FOR LOCATION OF DRAIN MATERIALS 1 AND 2.
5. SEE FIGURE 6 FOR COLLECTOR AND BLANKET DRAIN LAYOUT.



SECTION C
FIG. 2

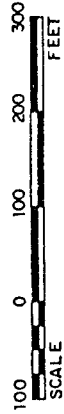
SECTION D
FIG. 2

MATERIAL TYPES	
SYMBOL	DESCRIPTION
①	DRAIN MATERIAL 1 - GRAVELLY SAND (SEE NOTE 4)
②	DRAIN MATERIAL 2 - GRAVEL (SEE NOTE 4)
③	COMPACTED TAILINGS SAND
④	RANDOM FILL - OR MOENKOPI SILTSTONE



SECTION E
FIG. 2

SECTION F
FIG. 2



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CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MEMBER OF THE
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

DAM CROSS - SECTIONS

ECO NO.	2151D - DGI
SHEET	OF
5	8
REV.	1
FIGURE 5	



LEGEND:

- BLANKET DRAIN
- COLLECTOR DRAIN
- FINAL REGRADED CONTOUR (ELEVATION OF DRAIN FOUNDATION)

NOTE:

1. DRAIN LOCATIONS SHALL BE FIELD FIT TO CONFORM TO EXISTING TOPOGRAPHY. MINIMUM DRAIN SLOPES SHALL BE AS SHOWN ON FIGURE 7.
2. SEE FIGURE 5 FOR MATERIAL TYPES AND DESCRIPTIONS.
3. SEEPAGE COLLECTION PONDS AND DIVERSION CHANNEL TO BE DESIGNED BY OTHERS.
4. SOFT AND DELETERIOUS MATERIALS TO BE REMOVED AND REPLACED WITH COMPACTED FILL.

TABLE 1

COLLECTOR DRAIN	ELEVATION A (FEET)
14F	5720
6C	5750
1F	5775

TOE DIKE DETAIL



PROFILE THROUGH NORTH DRAINAGE



PROFILE THROUGH SOUTH DRAINAGE



CONSULTING ENGINEERS



INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED CEB VHP CHECKED MPF
APPROVED PUG
DATE APRIL 1985

NO.	DATE	REVISIONS	BY	CHK	APPD	PKC
2	8-6-85	REVISED-RE-ISSUED FOR APPROVAL	CEB	GGC		PKC
1	5-14-85	ISSUED FOR APPROVAL	CEB	MPF		PKC
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	CEB	MPF		PKC

NO.	DATE	REVISIONS	BY	CHK	APPD	PKC
2	8-6-85	REVISED-RE-ISSUED FOR APPROVAL	CEB	GGC		PKC
1	5-14-85	ISSUED FOR APPROVAL	CEB	MPF		PKC
0	4-30-85	ISSUED FOR REVIEW AND COMMENT	CEB	MPF		PKC

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

DRAINAGE SYSTEM PLAN & PROFILE

ECO NO.	2151D - DG1
SHEET	6
OF	8
REV.	1
FIGURE	6

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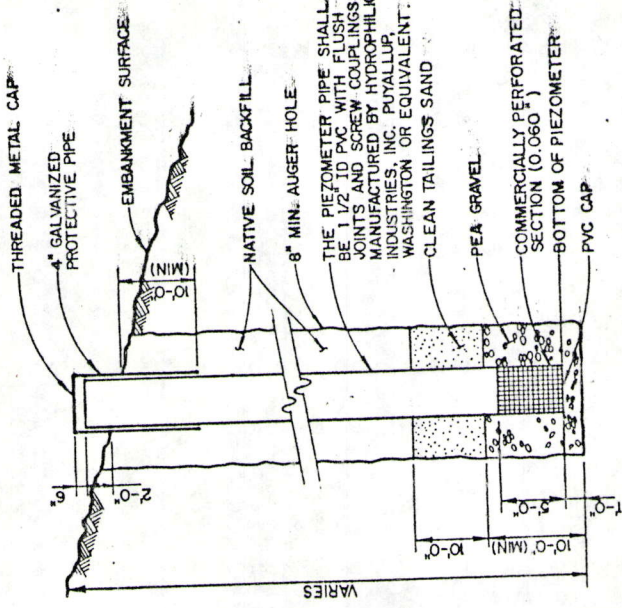
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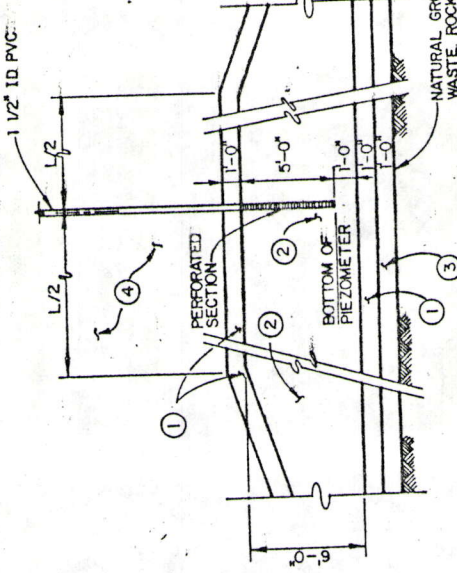
LEGEND:

- II WEIR LOCATION
- 2 PIEZOMETER LOCATION WITH CREST EL. 5900
- 5 PIEZOMETER LOCATION WITH CREST EL. 5930
- 1 MATERIAL TYPE (SEE FIGURE 5 FOR DESCRIPTION)



STANDPIPE PIEZOMETER DETAIL

NOT TO SCALE

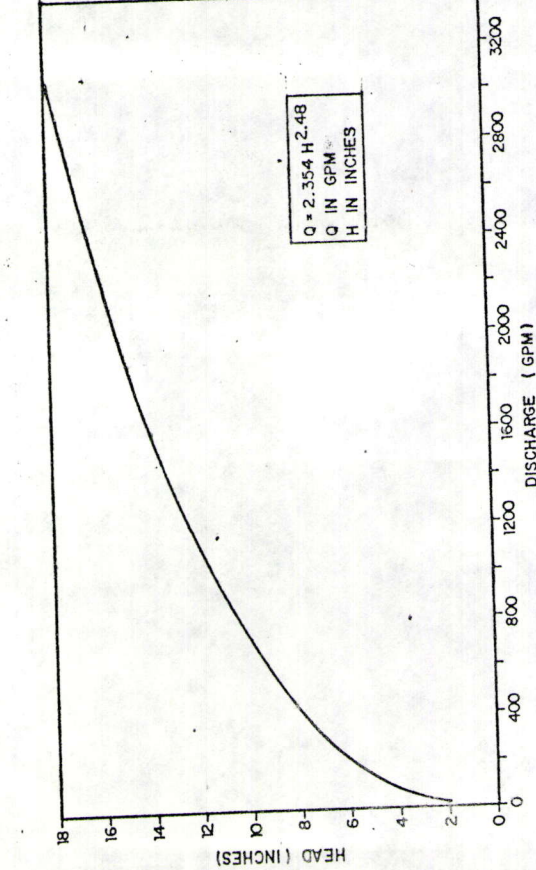


DRAIN DETAIL

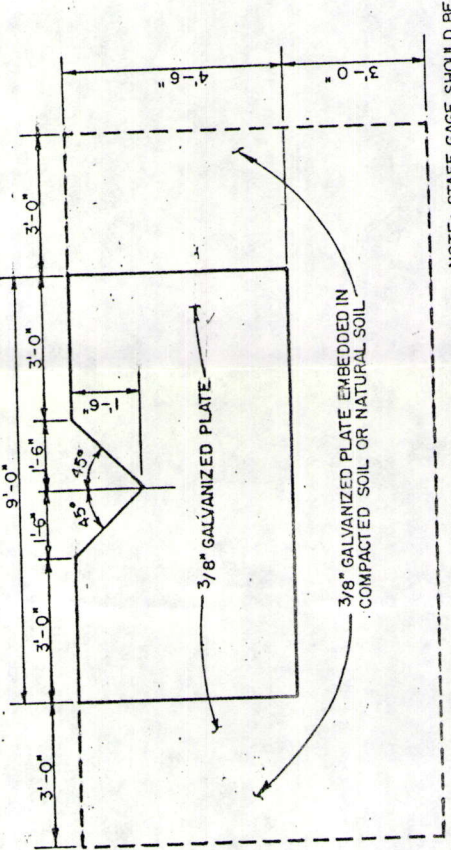
NOT TO SCALE

TABLE 1		
PIEZOMETER	L (FT.)	TIP ELEVATION
1	16	5743
2	8	DETERMINE IN FIELD
3	16	5808
4	20	5732
5	8	DETERMINE IN FIELD
6	20	5796

NOTE:
1. IN LOCAL AREAS OF PIEZOMETER IN ALLIGATION THE THICKNESS OF THE DRAIN MATERIAL #2 SHALL BE INCREASED TO 6 FT. THE LENGTH L OF THIS SECTION SHALL BE AS SHOWN IN TABLE 1.



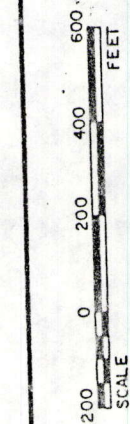
SEEPAGE WEIR DISCHARGE RATING CURVE



SEEPAGE WEIR DETAIL

NOTE: STAFF GAGE SHOULD BE PLACED AT LEAST 5 FEET FROM THE WEIR.

SCALE



REVISIONS		NO.	DATE
2	8-6-85	REVISED - RE - ISSUED FOR APPROVAL	
1	5-4-85	ISSUED FOR APPROVAL	
0	5-9-85	ISSUED FOR REVIEW AND COMMENT	

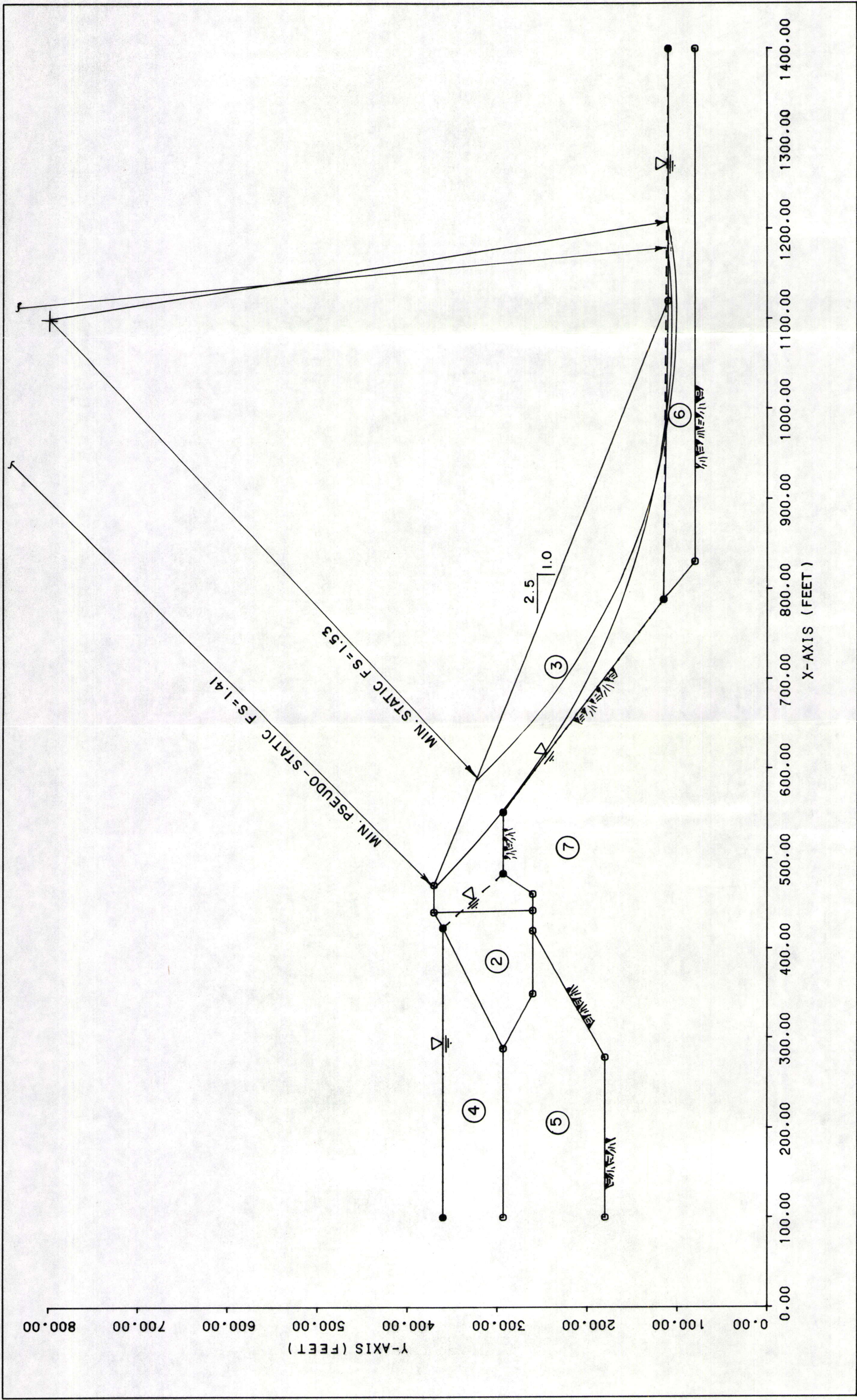
BY		CHK	APPD	DATE	APPROVED	PMG
CEB	SGC	PKC				
ASC	MPF	PMG				
ASC	MPF	PMG				

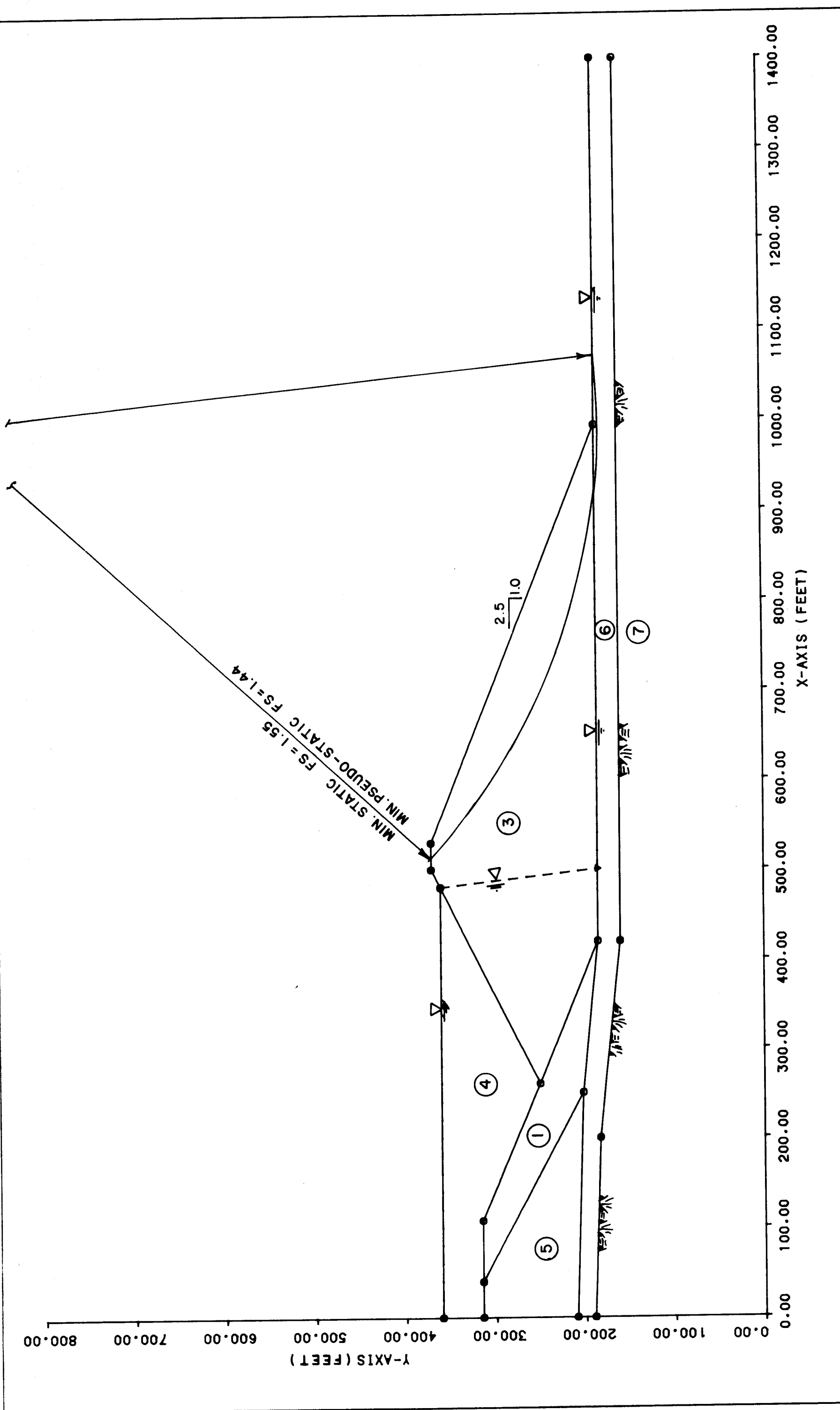
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWLAND STREET, SAN FRANCISCO, CALIFORNIA 94103
DESIGNED: ASC
DRAWN: CCB/VHP
CHECKED: MPF
RECOMMENDED: PKC
DATE: APRIL 1985

CHEVRON RESOURCES COMPANY
VERNAL PHOSPHATE PROJECT

INSTRUMENTATION PLAN & DETAILS

ECO NO.	2151D - DGI
SHEET	8
OF	8
REV.	1
FIGURE 8	





IECO SLOPE PROFILE SEE TABLE 1 FOR MATERIAL PROPERTIES (PAGE 4-3)	RESULTS OF STABILITY ANALYSIS SECTION F
----------------------------------------------------------------------	--------------------------------------------

APPENDIX A
BOREHOLE LOGS

DRILL LOG		PROJECT		JOB NO.		HOLE NO.		
		CHEVRON PHOSPHATE		2151		HA-1		
SITE		BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING			
TAILINGS DAM EXPANSION		10.0 AM 4-9-85	2.0 PM 4-9-85	7 3/4	VERT.			
COORDINATES		DEPTH/EL. GROUND WATER		GROUND EL.	DEPTH/EL. TOP OF ROCK			
32128.3 N - 59068.4 E		NO WATER		5951.0	13 ±			
DRILLING CONTRACTOR		CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE			
ERICKSON - FORD		N/A	6	N/A	45.1			
DRILL MAKE AND MODEL		LOGGED BY:						
CME 55		A.S. CHRISTENSEN						
SAMPLE DATA				REMARKS	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY					
HSA 7 3/4"				HARD DRILLING IN GRAVEL & ROCK		2		TAILINGS
						4		CLAYEY SILT TO SANDY SILT WITH LITTLE GRAVEL, LIGHT BROWN TO TAN, MOIST
	35 40 32	18"	14"	SAMPLE		6	SPT	ROCK, GRAY, HARD
						8		LAYERS OF SILTY GRAVEL AND GRAVELLY SILT, TAN, DRY. GRAVEL LAYERS ARE VERY DENSE.
	50/3	3"	0			10	SPT	
						12		SILTSTONE WITH TRACE OF FINE GRAVEL, TAN, NEARLY DRY
						14		
	45 50/3	9"	9"	SAMPLE		16	SPT	
						18		
						20	SPT	
	50/5	5"	5"	SAMPLE		22		
						24		SILTSTONE, GRAY, HARD, DRY
	50/2	2"	1"	WASTED		26	SPT	
						28		

HOLE NO.
HA-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG				PROJECT <u>CHEVRON PHOSPHATE</u>		JOB NO. <u>2151</u>		HOLE NO. <u>HA-1</u>	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FDT	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
HSA 7 3/4"	50/2	2"	2"	HARDER DRILLING FROM 28'		30			SILTSTONE, GRAY, HARD, DRY
				SAMPLE		32			
						34			
	50/2	2"	0"			36			
						38			
	50/1	1"	1"	WASTED		40			
						42			
						44			
	50/1			SAMPLE		46			BOTTOM OF HOLE 45.1 ↗
						48			
						50			
						52			
						54			
						56			
						58			
						60			

HOLE NO.
HA-1

SHEET 1 OF 2

DRILL LOG		PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-2	
SITE TAILINGS DAM EXPANSION		BEGUN 2.30 P 4-9-85	COMPLETED 11.30 A 4-10-85	HOLE SIZE 7 3/4	ANGLE FROM HORIZ. & BEARING VERT.	
COORDINATES 32141.6 N - 59959.6		DEPTH TO GROUND WATER 28.2'		GROUND EL. 5921.5	DEPTH TO TOP OF ROCK 12.5	
DRILLING CONTRACTOR ERICKSON - FORD		CORE RECOV. LENGTH/% 5.0' - 100%	SAMPLES 6	CORE BOXES ONE	DEPTH TO BOTTOM OF HOLE 45.1	
DRILL MAKE AND MODEL CME 55		LOGGED BY: A.S. CHRISTENSEN				
SAMPLE DATA						
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	
					DEPTH FT	
HSA, 7 3/4"						
					2	
					4	
	3 4 5	18"	18"	SAMPLE	6 SPT	
					8	
	PUSH	24"	17"		10 SPT	
	10 30 23	18"	16"	SAMPLE OF SILTSTONE	12 SPT	
					14	
	50/5	5'	5"	SAMPLE	16 SPT	
					18	
	28 46 50/5	17"	17"	SAMPLE	20 SPT	
				SMOOTH, MED. HARD DRILLING WITH AUGER	22	
					24	
	50/5	5"	5"	WASTED	26 SPT	
					28	
MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION					ROAD FILL, SILT SAND & GRAVEL	
					SANDY SILT, TAN, WITH TRACE OF FINE GRAVEL, SLIGHTLY WET.	
					SILT WITH SOME GYPSUM AND TRACE OF FINE SAND, BROWN TO GRAY BROWN, SLIGHTLY WET.	
					SILTSTONE WITH TRACE OF GRAVEL AND GYPSUM, MOIST TO NEARLY DRY, GRAY.	

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151		HOLE NO. HA-2	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
HSA 7 3/4"				W.L. 4' 10" 28.2'					
	5 1/2"	5"	5"	SAMPLE HARD DRILLING WITH AUGER		30	SP		
						32			
						34			
	5 1/2"	2"	0	4-9-85 4-10-85		36	SP		SILTSTONE, GRAY, MOIST TO DRY.
						38			
						40	SP		
NW CORE 2" DIA.	50/	1"	2"	SAMPLE		42			SILTSTONE, VERY FRACTURED AND CRUMBLING WITH MANY GYPSUM LENSES TO 1/4" MAX.
	RUN 1"	50'	5.0'	RQD = 30%		44			
						46			BOTTOM OF HOLE 45.1 ↗
						48			
						50			
						52			
						54			
						56			
						58			
						60			

HOLE NO.
HA-2

DRILL LOG		PROJECT		JOB NO.		HOLE NO.		
		CHEVRON PHOSPHATE		2151		HA-3		
SITE		BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING			
TAILINGS DAM EXPANSION		12.45 PM	3.15 PM	7 3/4"	VERT.			
COORDINATES		DEPTH/EL. GROUND WATER		GROUND EL.	DEPTH/EL. TOP OF ROCK			
31821.0 N - 60650.9 E		22' ±		5799.6	9.5'			
DRILLING CONTRACTOR		CORE RECOV. LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE			
ERICKSON - FORD		N/A	3	N/A	30.1			
DRILL MAKE AND MODEL		LOGGED BY:						
CME 55		A.S. CHRISTENSEN						
SAMPLE DATA				REMARKS	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N. BLOW COUNT	ADVANCE	RECOVERY					
HSA 7 3/4"						2		SILT WITH MUCH ORGANIC MATERIAL IN TOP 9 INCHES, GRAY, MOIST TO WET
						4		GRADING TO
	P U S H	24"	24"			6	SHE LL S O FT	
	7 17 45	18"	18"	SAMPLE		8	SP T	CLAYEY SILT WITH GYPSUM AND GYPSUM LENSES TO 1/4" MAX, GRAY, SLIGHTLY WET TO MOIST.
	50/3	3"	0	SMOOTH BUT QUITE HARD DRILLING		10	SP T	
						12		
	50/3	3"	0			14	SP T	SILTSTONE, GRAY, HARD NEARLY DRY
						16		
	50/3	3"	3"	SAMPLE		18		CHANGING TO
						20	SP T	
						22		
						24		
	50/2 1/2	2 1/2"	2"	SAMPLE		26	SP T	GRAY TO GRAY BROWN, WET.
						28		

HOLE NO.
HA-3

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151		HOLE NO. HA-3	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
HSA 7 3/4						30		SILTSTONE WITH HARD GRAVEL SIZE FRAGMENTS, GRAY, WET.	
	50/1"	1"	1"			30.1		BOTTOM OF HOLE 30.1	
						32			
						34			
						36			
						38			
						40			
						42			
						44			
						46			
						48			
						50			
						52			
						54			
						56			
						58			
						60			

HOLE NO.
HA-3

DRILL LOG		PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-4
SITE TAILINGS DAM EXPANSION		BEGUN 4.0 PM 4-10-85	COMPLETED 9.0 AM 4-11-85	HOLE SIZE 7 3/4	ANGLE FROM HORIZ. & BEARING VERT.
COORDINATES 31414.1 N - 61373.7 E		DEPTH/EL. GROUND WATER NO WATER		GROUND EL. 5891.9	DEPTH/EL. TOP OF ROCK 5 ±
DRILLING CONTRACTOR ERICKSON - FORD		CORE RECOV. LENGTH/% 5.0' 100%	SAMPLES ONE	CORE BOXES ONE	DEPTH/EL. BOTTOM OF HOLE 24.5'
DRILL MAKE AND MODEL CME 55		LOGGED BY: A.S. CHRISTENSEN			
SAMPLE DATA				MATERIAL CLASSIFICATION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	ELEVATION	DEPTH FT
REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH				PHYSICAL DESCRIPTION	
HSA 7 3/4"					
					ROAD FILL, SAND & GRAVEL
					SILT, LOOSE, MOIST & GRAY
	20 21 25	10"	18"		6
	50 5	5"	1"		10
					12
					14
	50 2	2"	0		16
					18
					20
NW CORE 2"DIA	RUN #1		5' 5'		22
					24
					26
					28
					30
					32
					34
					36
					38
					40
					42
					44
					46
					48
					50
					52
					54
					56
					58
					60
					62
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					192
					194
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					198
					200
					202
					204
					206
					208
					210
					212
					214
					216
					218
					220
					222
					22

DRILL LOG		PROJECT		JOB NO.		HOLE NO.	
		CHEVRON PHOSPHATE		2151		HA-5	
SITE		BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING		
MIDDLE OF RETENTION POND DIKE		11:25 A 4-14-85	4:30 PM 4-14-85	7 3/4"	VERT.		
COORDINATES (SCALED)		DEPTH/EL. GROUND WATER		GROUND EL.		DEPTH/EL. TOP OF ROCK	
30069.0 62179.5		NOT DETERMINED		5731.5		50'	
DRILLING CONTRACTOR		CORE RECOV. LENGTH/%		SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE	
ERICKSON - FORD		N/A		7	NO CORE	50.0'	
DRILL MAKE AND MODEL		LOGGED BY:					
CME 55		A.S. CHRISTENSEN					

SAMPLE DATA				REMARKS	ELEVATION	DEPTH FT	LOG GRAPHIC	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
HSA 7 3/4"									<p>DIKE FILL: SILTY GRAVEL AND ROCKFILL</p> <p>SILT & GRAVEL, GRAY SATURATED</p> <p>GRADING TO</p> <p>SILT, REDDISH BROWN, WITH SOME ORGANIC MATERIAL, VERY WET.</p> <p>SILT WITH TRACE OF ORGANIC MAT'L, SATURATED</p> <p>SILT WITH LITTLE COARSE SAND, REDDISH BROWN</p>
				EASY AUGERING					
	PUSH	24"	6"	CUTTING EDGE OF TUBE BADLY BENT, SAMPLE WASTED					
	PUSH	18"	18"	REFUSAL AT 18"					
	3/4"	18"	12"	SAMPLE WASTED					
	1/18"	24"	0"	NO RECOVERY FROM SHELBY. SPT TAKEN IN SAME AREA, DISCOUNT BLOWCOUNT					
	PUSH	24"	20"						
	2 3/8"	18"	18"	SAMPLE WASTED					

HOLE NO.
HA-5

DRILL LOG				PROJECT <u>CHEVRON PHOSPHATE</u>		JOB NO. <u>2151</u>		HOLE NO. <u>HA-5</u>	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD BLOW COUNT	ADVANCE	RECOVERY						
HSA 7 3/4"				EASY AUGERING		30	SHELLBY	MATERIAL BECAME HARDER AT 28' DEPTH	
	PUSH	24"	27"			32		SILT WITH COARSE GRAVEL AT BOTTOM OF TUBE.	
						34			
	PUSH	24"	0"	NO RECOVERY		36	SHELLBY		
	PUSH	24"	24"			38			
	B 12 15	18"	18"			40		SANDY GRAVELLY SILT, BROWN WITH FEW GRAY LAYERS, VERY WET TO SATURATED.	
				SAMPLE HARD AUGERING TO 43'		42	SP		
						44			
						46		SANDY SILT, REDDISH BROWN	
	PUSH	19"	22"	EASIER AUGERING TO 48'		48	SP		
						50		WEATHERED SILTSTONE WITH GYPSUM LENSES, HARD, BROWN,	
						52		BOTTOM OF HOLE 50.0 ↗	
	50 4 1/2	4 1/2"	4 1/2"	SAMPLE HARD AUGERING. REFUSAL AT 49.7'		54	SP		
						56			
						58			
					60				

HOLE NO.
HA-5

DRILL LOG		PROJECT <u>CHEVRON PHOSPHATE</u>		JOB NO. <u>2151</u>		HOLE NO. <u>HA-6</u>	
SITE <u>TAILINGS DAM EXPANSION</u>		BEGUN <u>9.35 AM</u> <u>4-11-85</u>	COMPLETED <u>11.20 AM</u> <u>4-11-85</u>	HOLE SIZE <u>7 3/4</u>	ANGLE FROM HORIZ. BEARING <u>VERT.</u>		
COORDINATES <u>30096.1 N - 61945.8 E</u>		DEPTH/EL. GROUND WATER <u>NO WATER</u>		GROUND EL. <u>5758.9</u>	DEPTH/EL. TOP OF ROCK <u>0'</u>		
DRILLING CONTRACTOR <u>ERICKSON - FORD</u>		CORE RECOV. LENGTH/% <u>4'-6" 90%</u>		SAMPLES <u>2</u>	CORE BOXES <u>ONE</u>	DEPTH/EL. BOTTOM OF HOLE <u>20.1</u>	
DRILL MAKE AND MODEL <u>CME 55</u>		LOGGED BY: <u>A.S. CHRISTENSEN</u>					
SAMPLE DATA		REMARKS		ELEVATION	DEPTH FT	GRAPHIC LOG	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY				
<u>HSA</u> <u>7 3/4"</u>					<u>2</u>		<u>SILTSTONE, GRAY AND REDDISH BROWN, LAYERED, OCCASIONAL WITH FEW PIECES OF GRAVEL AND TRACE OF GYPSUM, NEARLY DRY</u>
					<u>4</u>		
	<u>50</u> <u>1"</u>	<u>1"</u>	<u>2"</u>	<u>SAMPLE</u> <u>GRAY SILTSTONE</u>		<u>50</u> <u>1"</u>	
					<u>8</u>		
	<u>50</u> <u>4"</u>	<u>4"</u>	<u>4"</u>	<u>SAMPLE</u> <u>REDDISH BROWN</u>		<u>50</u> <u>4"</u>	
					<u>12</u>		
					<u>14</u>		
<u>NW</u> <u>CORE</u> <u>2" DIA.</u>	<u>50</u> <u>1 1/2</u>	<u>1 1/2</u>	<u>1 1/2</u>	<u>NO SAMPLE</u>		<u>50</u> <u>1 1/2</u>	<u>SILTSTONE WITH MANY HAIRLINE GYPSUM SEAMS, VERY FRACTURED. HARDNESS OF CORE VARY, SOFT ZONE 17.5' TO 17.8'</u>
	<u>R</u> <u>2"</u>	<u>50</u> <u>4'-6"</u>		<u>RQD: 45%</u>		<u>50</u> <u>4'-6"</u>	
					<u>20</u>		<u>BOTTOM OF HOLE 20.1</u>
					<u>22</u>		
					<u>24</u>		
					<u>26</u>		
					<u>28</u>		

HOLE NO.
HA-6

DRILL LOG		PROJECT		JOB NO.		HOLE NO.	
		CHEVRON PHOSPHATE		2151		HA-7	
SITE		BEGUN	COMPLETED	HOLE SIZE	ANGLE FROM HORIZ. & BEARING		
BORROW AREA		12.45 PM 4-11-85	11.50 A 4-12-85	2"	VERT.		
COORDINATES		DEPTH/EL. GROUND WATER		GROUND EL.	DEPTH/EL. TOP OF ROCK		
29458.7 N - 60352.5 E		35' ±		5901.8	4.0'		
DRILLING CONTRACTOR		CORE RECOV. LENGTH/%		SAMPLES	CORE BOXES	DEPTH/EL. BOTTOM OF HOLE	
ERICKSON - FORD		64' 100% N/A		5	73.5'		
DRILL MAKE AND MODEL		LOGGED BY:					
CME 55		A.S. CHRISTENSEN					
SAMPLE DATA		REMARKS		ELEVATION	DEPTH	GRAPHIC LOG	MATERIAL CLASSIFICATION
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT ADVANCE RECOVERY	WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH			FT		PHYSICAL DESCRIPTION
HSA 7 3/4"					2		SILT, REDDISH BROWN, MOIST
					4		
					6		SILTSTONE, WEATHERED, MOIST
					8		GRADING TO
NW CORE 2" DIA	RUN #1 4.0'				10		FRACTURED, MED HARD
					12		SILTSTONE WITH SOME GYPSUM, HARD, LIGHT BROWN & GRAY MOTTLED
					14		GYPSUM WITH SOME SILTSTONE, WHITE MED. HARD.
	RUN #2 5.0'	GOOD WATER RETURN			16		SILTSTONE WITH SEVERAL GYPSUM LENSES TO 1/4", VERY FRACTURED, MED. HARD, BROWN.
					18		MIXTURE OF SILTSTONE AND SAND- STONE WITH SOME GYPSUM, MOTTLED AND LAYERED, VERY IRREGULAR, REDDISH BROWN TO WHITE MED. HARD. VERT. AND HOR. FRACTURES.
	RUN #3 5.0'				20		SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" MAX. MED HARD FROM BROWN TO GRAY BROWN, LAYERED. VERY FRACT 19.5 - 20.3 AND 23.0 - 27.6
					22		
	RUN #4 5.0'				24		
					26		
					28		SANDSTONE, SILTSTONE AND GYPSUM. LT. BROWN TO GRAY MOTTLED, HARD. VERY IRREGULAR COLORING

HOLE NO.
HA-7

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151		HOLE NO. HA-7	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
NW CORE 2" DIA				GOOD WATER RETURN		30		SEE SHEET 1	
	RUN #5	50' 5.0'		RQD: 50%		32	Box #2	SANDSTONE AND SILTSTONE, BROWN TO GRAYISH LAYERED VERY FRACTURED TO FRACT. WITH MANY GYPSUM LENSES FROM HAIRLINE TO 3/16" MAX. MED HARD TO HARD WITH A 1" SOFT ZONE AT 32.3'. 1/2" GYPSUM LENSE @ 42.5'	
	RUN #6	50' 5.0'		W.L. 4 1/2 - 85 RQD: 65%		34			
	RUN #7	50' 5.0'		RQD: 50%		36			
	RUN #8	50' 5.0'		RQD: 33%		38			
	RUN #9	50' 5.0'		RQD: 38%		40	Box #3	SANDSTONE & SILTSTONE, FRACT. W/ MANY THIN GYPSUM LENSES TO 1/4" MAX. BROWN	
	RUN #10	50' 5.0'		RQD: 75%		42		SILTSTONE, VERY FRACT. & SOFT WITH SEVERAL GYPSUM LENSES TO 1/8" MAX REDDISH BROWN. CRUMBLING ZONE 47.2 TO 48.2'	
				GOOD WATER RETURN		44		SILTSTONE & SOME SANDSTONE WITH SEVERAL GYPSUM LENSES TO 3/8" MAX, VERY FRACT. TO FRACT. COLOR FROM BROWN TO GRAYISH.	
						46			
						48			
						50			
						52			
						54	Box #4	SILTSTONE, FRACT., WITH MANY GYPSUM LENSES TO 1/8" MAX., MED. HARD TO HARD, BROWNISH	
						56			
						58			
						60			

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151		HOLE NO. HA-7	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
NW CORE	RUN #11	5.0	5.0	RQD: 80%		62	BOX #4	SILTSTONE, FRACTURED, WITH SEVERAL GYPSUM LENSES TO 1/8", A 3/8" GYPSUM LENSE IN SOFT SILTST. 59.3'. ONE 3/8" LENSE AT 64.3, ONE 1/4" LENSE AT 72.7. SOFT SEAM AT 59.7 SOFT AREA 64.0' - 64.7' REDDISH BROWN TO BROWN, MED. HARD TO HARD	
	RUN #12	5.0	5.0	GOOD WATER RETURN RQD: 83%		64 66 68			
	RUN #13	5.0	5.0	RQD: 93%		70 72 74	BOX #5		
						76 78 80			
								BOTTOM OF HOLE 73.5	

DRILL LOG		PROJECT <u>CHEVRON PHOSPHATE</u>				JOB NO. <u>2151</u>		HOLE NO. <u>HA-8</u>	
SITE <u>BORROW AREA</u>				BEGUN <u>12.30 PM</u> <u>4-12-85</u>		COMPLETED <u>9.45 AM</u> <u>4-14-85</u>		HOLE SIZE <u>2"</u>	
COORDINATES <u>29259.3N - 59422.2</u>				DEPTH/EL. GROUND WATER <u>27'</u>		GROUND EL. <u>5929.6</u>		ANGLE FROM HORIZ. & BEARING <u>VERT.</u>	
DRILLING CONTRACTOR <u>ERICKSON - FORD</u>				CORE RECOV. LENGTH/%		SAMPLES		CORE BOXES	
DRILL MAKE AND MODEL <u>CME 55</u>				LOGGED BY: <u>A.S. CHRISTENSEN</u>					
SAMPLE DATA				REMARKS		ELEVATION		DEPTH	
TYPE TOOL AND DIA.		METHOD N-BLOW COUNT		ADVANCE		RECOVERY		GRAPHIC LOG	
								BOX/SAMPLE NO.	
								MATERIAL CLASSIFICATION	
								PHYSICAL DESCRIPTION	
HSA 7 3/4"									
				EASY DRILLING		2		SILT, LOOSE, MOIST REDDISH BROWN	
						4			
						6		SILTSTONE, WEATHERED REDDISH BROWN, SOFT	
						8			
						10			
N/W CORE 2" DIA		RUN #1		4.0 4.0		12		SILTSTONE WITH FEW GYPSUM LENSES TO 1/16", ONE 1/4" LENSE AT 10.3', VERY FRACT., SOFT TO MED. HARD, REDDISH BROWN.	
		RUN #2		5.0 5.0		14		BOX #1	
				GOOD WATER RETURN RQD: 27%		16			
		RUN #3		5.0 5.0		18			
				RQD: 62%		20		SILTSTONE WITH MANY GYPSUM LENSES TO 1/8" - ONE 3/8" LENSE AT 21.0'. SOFT & CRUMBLING 21.0-21.2 AND 22.7' - 23.5. MED HARD & FRACTURED TO VERY FRACT.	
		RUN #4		4.0 4.0		22			
				GOOD WATER RETURN RQD: 52%		24		SILTSTONE AND SANDSTONE WITH MANY GYPSUM LENSES AND POCKETS. BROWN TO LIGHT GRAY, HARD.	
				LOST CIRCULAT 26'-27'		26		BOX #2	
				RQD: 59		28		SILTSTONE AND GYPSUM, VERY LAMINATED, GRAY AND BROWN, HARD.	
								SILTSTONE WITH MANY GYPSUM LAYERS AND LENSES TO 1/2" MAX. SOFT & CRUMBLING, BROWN.	
								HOLE NO. HA-8	

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151		HOLE NO. HA-8	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION	
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY						
NW CORE									CORE LOSS BETW 27.2 & 28.8
	RUN #5	5.0	5.0	FAIR TO POOR WATER RETURN RQD: 70% NO WATER RETURN		30 32 34	BOX #2		SILTSTONE WITH GYPSUM LAYERS AND POCKETS, SLIGHTLY FRACT., LT. GRAY TO BROWN, COLORS INTERMIXED. HARD.
	RUN #6	5.0	5.0	RQD: 85%		36 38 40			SILTSTONE WITH MANY GYPSUM LENSES TO 3/8" MAX, GRAY BROWN TO BROWN, HARD
	RUN #7	5.0	4.9	RQD: 92%		42	BOX #3		SILTSTONE WITH LITTLE GYPSUM, LT. GRAY TO BROWN, MARBLED AND LAMINATED, HARD
	RUN #8	5.0	5.0	RQD: 92%		44 46 48			SILTSTONE WITH MANY GYPSUM LENSES TO 1/8" MAX, GRAY & BR LAYERED AND MARBLED. FRACT. WITH 2 SOFT JOINTS. GYPSUM & SILTSTONE MIXED, GRAY-BR.
	RUN #9	4.1	4.1	RQD: 94%		50 52 54	BOX #4		SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" AND OCCASIONAL 1/2" LENSE, FRACT., HARD, GRAY BROWN TO BROWN.
	RUN #10	5.2	5.2	RQD: 81% NO WATER RETURN		56 58 60	BOX #5		

HOLE NO.
HA-8

DRILL LOG				PROJECT CHEVRON PHOSPHATE		JOB NO. 2151	HOLE NO. HA-8	
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY					
NWY CORE	RUN 11	52	52	NO WATER RETURN RQD: 87%		62		SILTSTONE WITH MANY GYPSUM LENSES FROM HAIR- LINE TO 1/8", ONE 1/2" LENSE AT 64.0', ONE 3/4" LENSE AT 65.0', FRACT., HARD. GRAY BROWN TO BROWN.
	RUN 12	53	52	RQD: 86%		64 66 68		
	RUN 13	52	52	RQD: 68%		70 72 74	SILTSTONE WITH MANY GYPSUM LENSES FROM HAIRLINE TO 1/8" WITH OCCASIONAL 1/4" LENSE. FRACT., MED HARD TO HARD WITH SEVERAL SOFT JOINTS 72.7 TO 74.0 GRAY BROWN TO DARK BROWN.	
	RUN 14	50	50	RQD: 87%		76 78		
	RUN 15	50	50	RQD: 80%		80 82 84		
	RUN 16	50	50	RQD: 92%		86 88		
				NO WATER RETURN		90	SILTSTONE WITH SOME HAIRLINE GYPSUM LENSES. SEVERAL VERT. & HOR. LENSES 1/16" TO 3/16" SLIGHTLY FRACT., HARD. GRAY BROWN TO DARK BROWN	
	RUN 17	50	50	RQD: 88%		92		

HOLE NO.
HA-8

DRILL LOG				PROJECT		JOB NO.		HOLE NO.		
				CHEVRON PHOSPHATE		2151		HA-8		
SAMPLE DATA				REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH FT	GRAPHIC LOG BOX/SAMPLE NO.	MATERIAL CLASSIFICATION		
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY					PHYSICAL DESCRIPTION		
NW CORE						94	BOX 8	SEE SHEET 3		
	R N 18	5.0'	5.0'	NO WATER RETURN RQD: 82%		96		BOX 9	SILTSTONE WITH VERT & HOR. GYPSUM LENSES FROM HAIRLINE TO 3/8" MAX. SLIGHTLY FRACTURED, HARD, GRAY BROWN TO DARK BROWN.	
						98				
	R N 19	5.0'	5.0'	RQD: 95%		100				
						102				
						104				
						106				
						108				
						110				
								BOTTOM OF HOLE 104.0' ↗		

HOLE NO.
HA-8

APPENDIX B
LABORATORY TEST RESULTS

Laboratory Testing

CHEVRON PHOSPHATE FACILITIES

May 1985

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

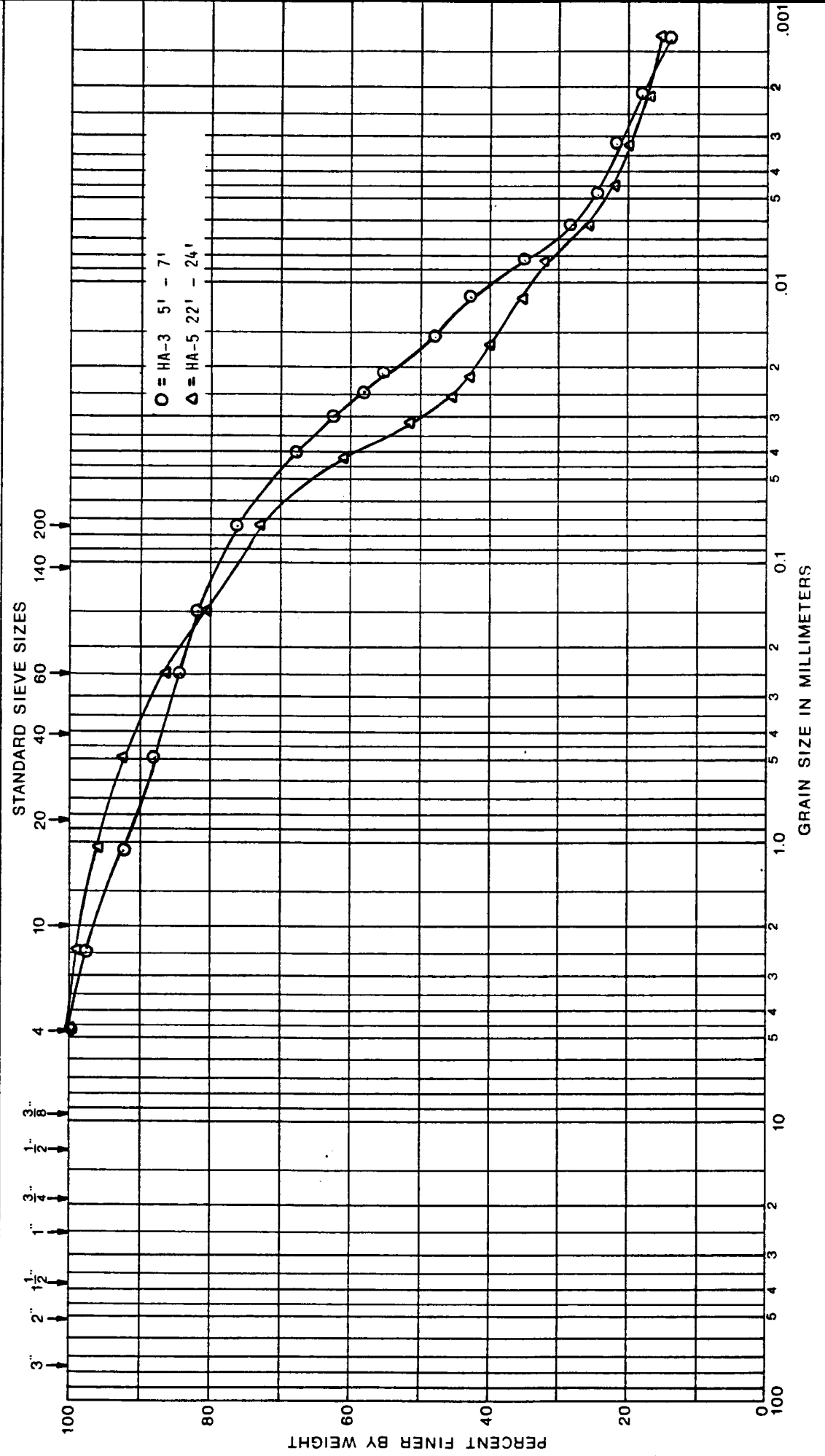
1435 West 820 North ■ P.O. Box 711 ■ Provo, Utah 84603
Telephone (801) 374-5771

Table No 6

Location Vernal, Utah

[illegible]

GRAVEL		SAND			SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE		

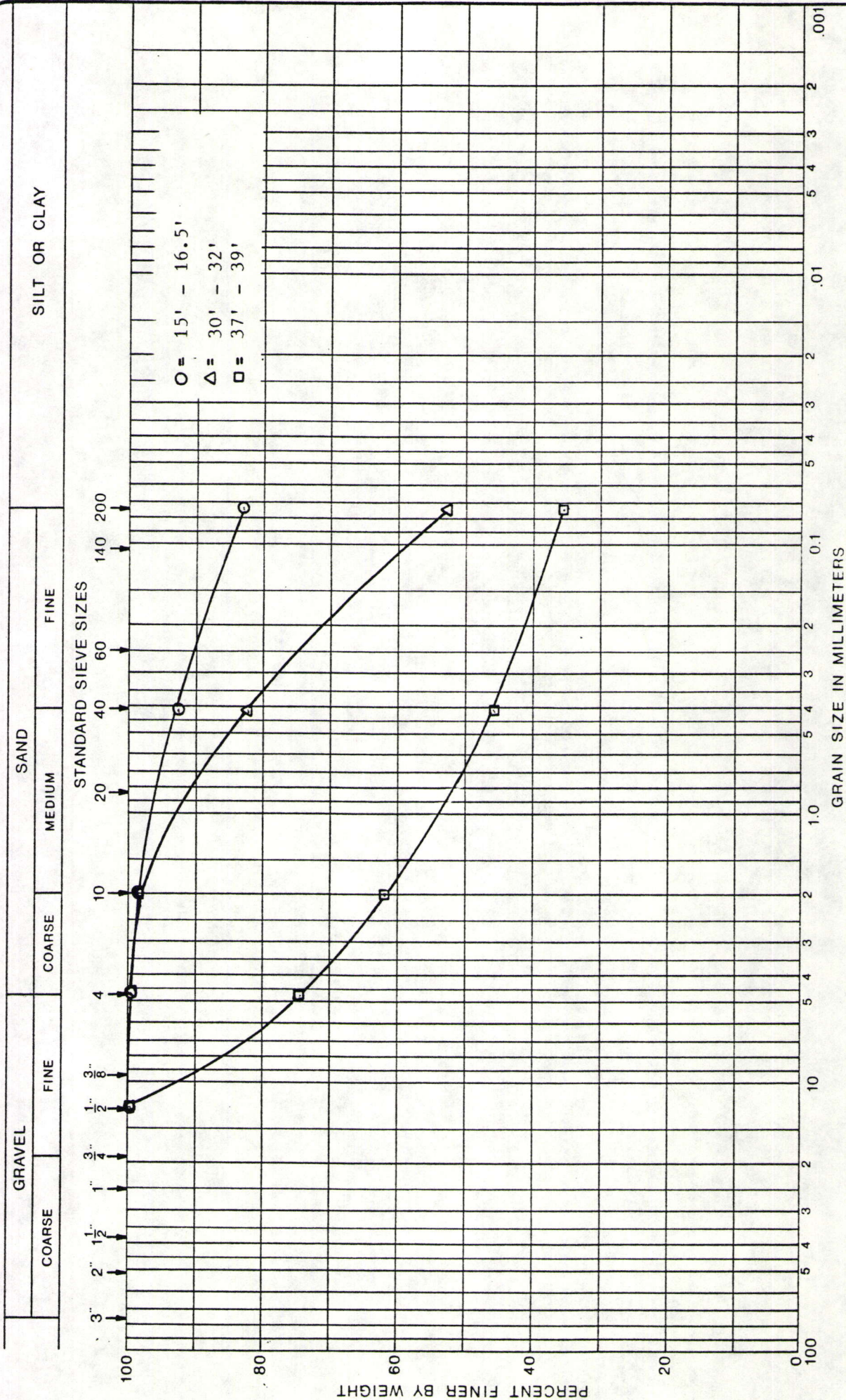


ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

GRAIN SIZE DISTRIBUTION CURVE
Project: CHEVRON PHOSPHATE FACILITIES
Location: Vernal, Utah

HOLE NO. HA-3
DEPTH: HA-5

FIGURE NO.



ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

GRAIN SIZE DISTRIBUTION CURVE

Project: CHEVRON PHOSPHATE FACILITIES
Location: Vernal, Utah

HOLE NO. HA-5
DEPTH:

FIGURE
NO.

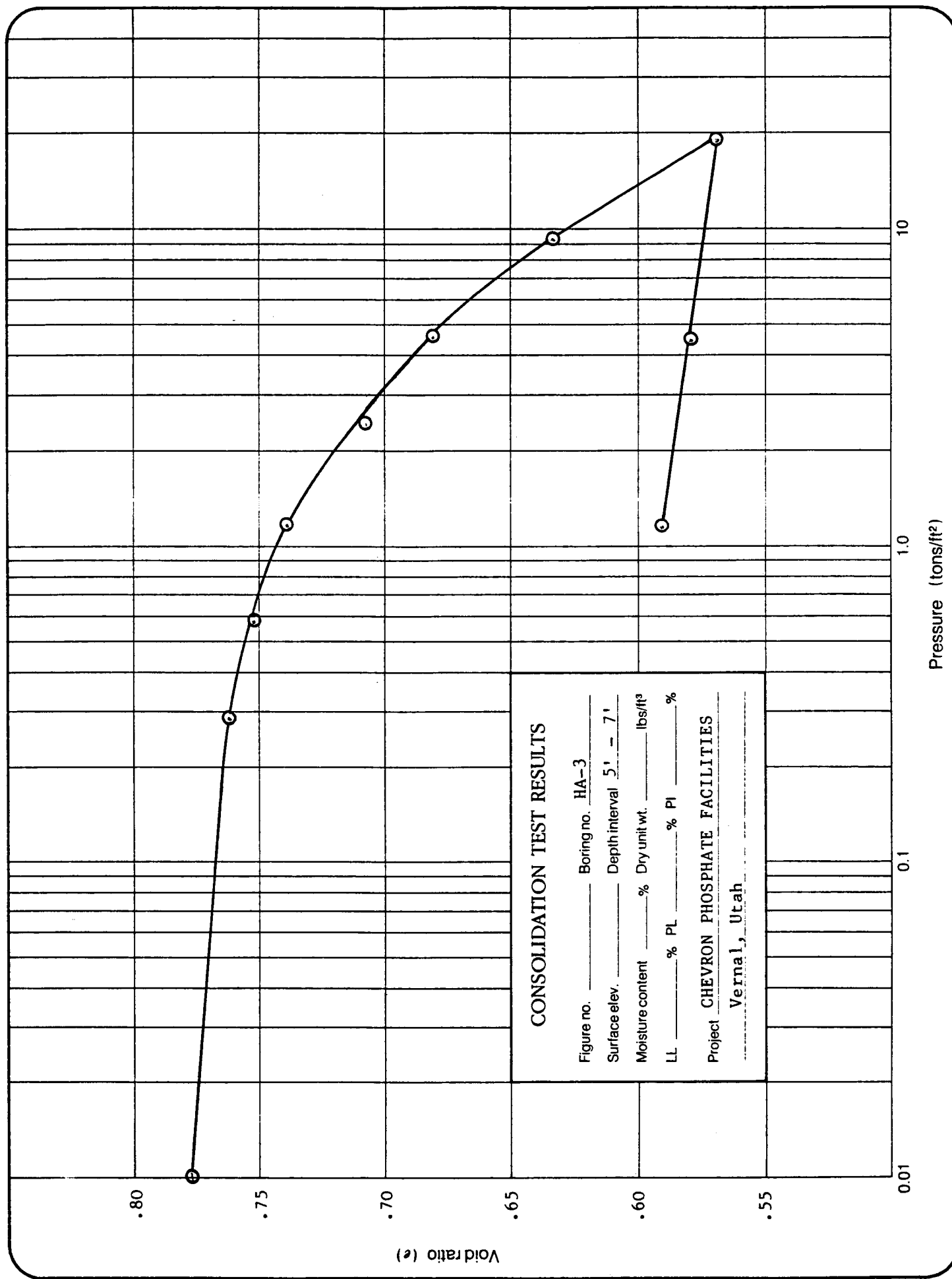


Table No. 1
Time Consolidation Tests
Sample HA-3, 5-7 feet

<u>Elapsed Time, min</u>	<u>Dial Reading</u>		
	<u>0.58 tsf</u>	<u>1.15 tsf</u>	<u>2.30 tsf</u>
0	.0395	.0457	.0528
.1	.0399	.0470	.0546
0.25	.0410	.0471	.0547
0.5	.0411	.0472	.0549
1	.0412	.0473	.0551
2	.0413	.0475	.0553
4	.0414	.0476	.0555
8	.0416	.0478	.0558
15	.0420	.0481	.0563
30	.0423	.0484	.0567
60	.0426	.0488	.0573
120	(180).0433	.0492	.0582
240		.0499	.0591
480	(434).0441	.0508	.0610
1420	(1414).0457	.0528	(1425).0699

Time Consolidation Test Cont.
Sample HA-3, 5-7 feet

<u>Elapsed Time, min</u>	<u>4.60 tsf</u>	<u>Dial Reading</u>	
		<u>9.20 tsf</u>	<u>18.40 tsf</u>
0	.0695	.0855	.1122
.1	.0722	.0896	.1180
0.25	.0724	.0900	.1189
0.5	.0726	.0908	.1195
1	.0730	.0912	.1203
2	.0731	.0919	.1213
4	.0734	.0928	.1224
8	.0737	.0937	.1235
15	.0741	.0946	.1250
30	.0749	.0959	.1264
60	.0756	.0977	.1282
120	.0767	.0997	.1315
240	.0782	.1019	.1342
480	.0801	.1051	(511) .1389
1420	(1443) .08055	(1418) .1122	(1448) .1478

Void ratio (e)

.55

.50

.45

.40

0.01

0.1

1.0

10

Pressure (tons/ft²)

CONSOLIDATION TEST RESULTS

Figure no. _____ Boring no. HA-5
Surface elev. _____ Depth interval 15' - 16.5'
Moisture content _____ % Dry unit wt. _____ lbs/ft³
LL _____ % PL _____ % PI _____ %
Project CHEVRON PHOSPHATE FACILITIES
Vernal, Utah

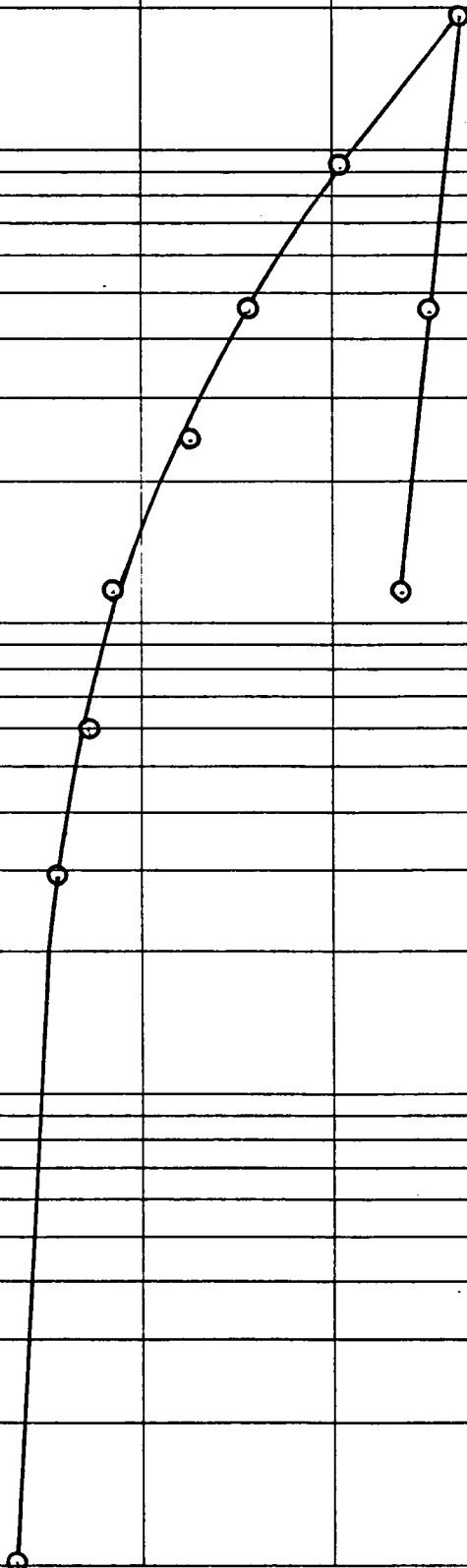
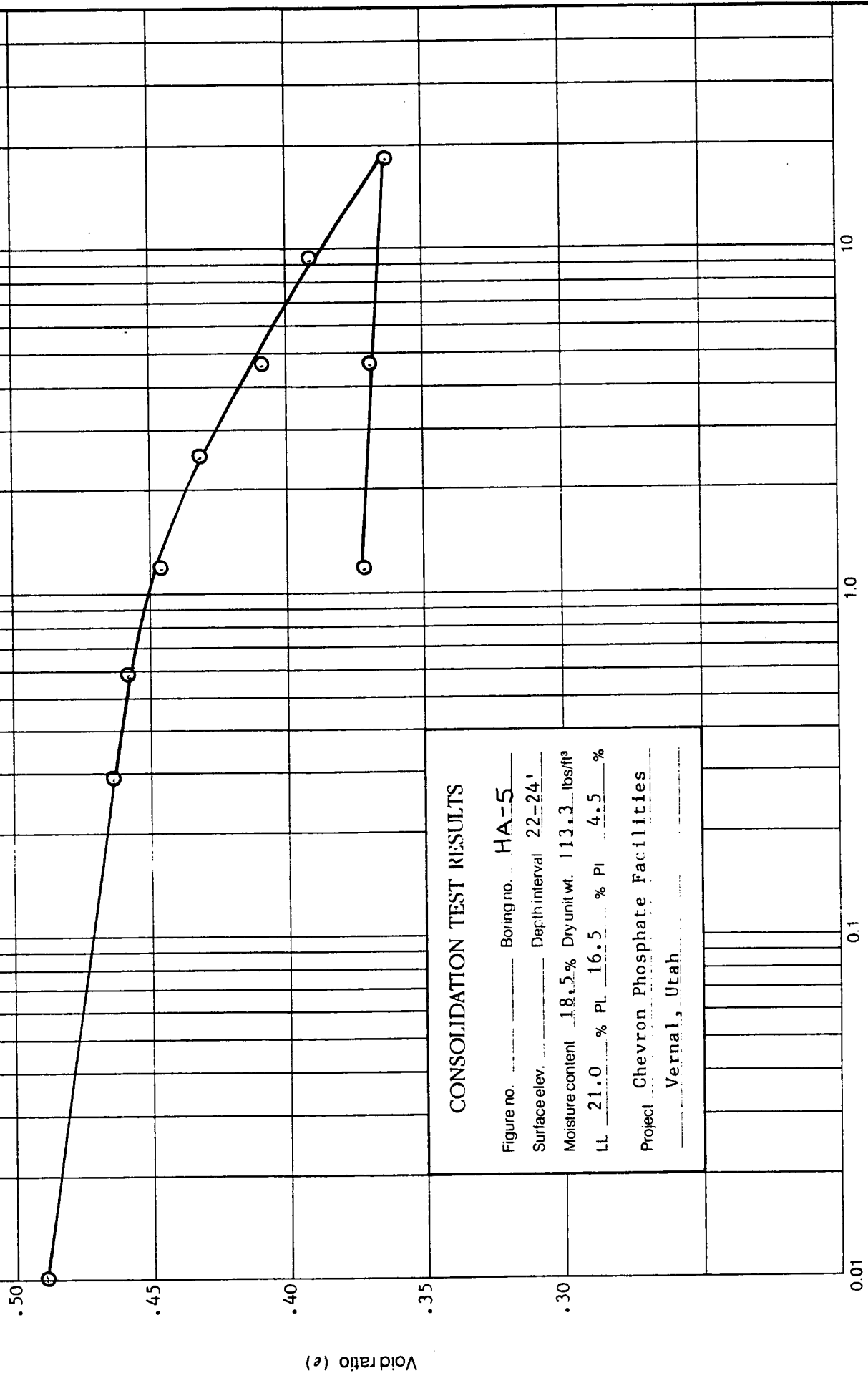


Table No. 2
Time Consolidation Test
Sample HA-5, 15-16.5 feet

<u>Elapsed Time, min.</u>	<u>0.58 tsf</u>	<u>Dial Reading</u>	
		<u>1.15 tsf</u>	<u>2.30 tsf</u>
0	.0544	.0596	.0664
.1	.0559	.0617	.0693
0.25	.0561	.0621	.0696
0.5	.0563	.0623	.0699
1	.0565	.0626	.0702
2	.0566	.0628	.0705
4	.0568	.0630	.0708
8	.0570	.0632	.0711
15	.0571	.0635	.0715
30	.0573	.0638	.0718
60	.0576	.0641	.0722
120		.0644	.0727
240	(180) .0581	.0648	.0733
480	(435) .0587	.0654	.0741
1420	(1415) .0596	(1422) .0664	(1426) .0764

Time Consolidation Test Cont.
Sample HA-5, 15-16.5 feet

<u>Elapsed Time, min.</u>	<u>Dial Reading</u>		
	<u>4.60 tsf</u>	<u>9.20 tsf</u>	<u>18.40 tsf</u>
0	.0764	.0872	.1027
.1	.0797	.0924	.1097
0.25	.0801	.0929	.1105
0.5	.0804	.0933	.1111
1	.0807	.0939	.1118
2	.0810	.0943	.1126
4	.0813	.0949	.1133
8	.0817	.0955	.1140
15	.0820	.0960	.1147
30	.0825	.0967	.1156
60	.0829	.0976	.1164
120	.0835	.0984	.1176
240	.0842	.0994	.1187
480	.0851	.1004	(513) .1204
1420	(1444) .0872	.1027	(1447) .1230



CONSOLIDATION TEST RESULTS

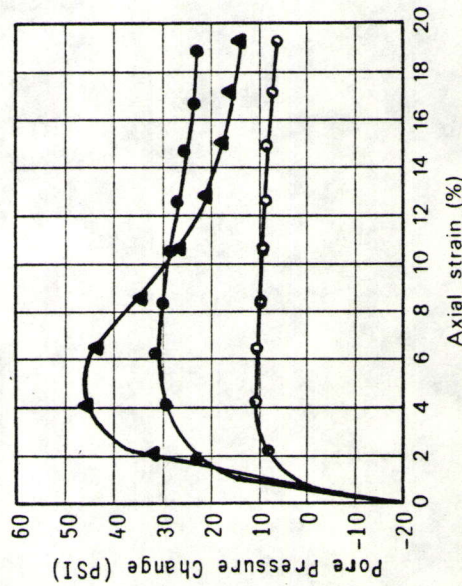
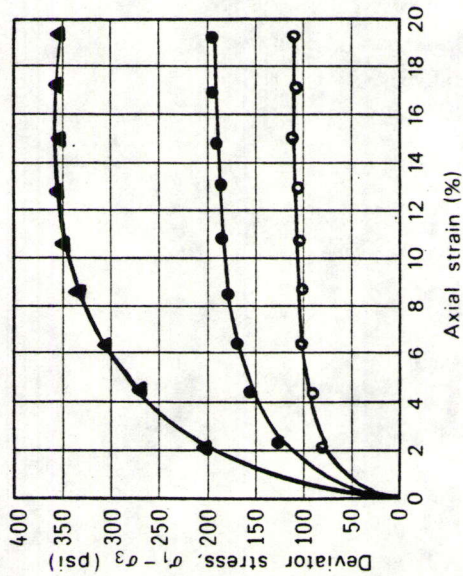
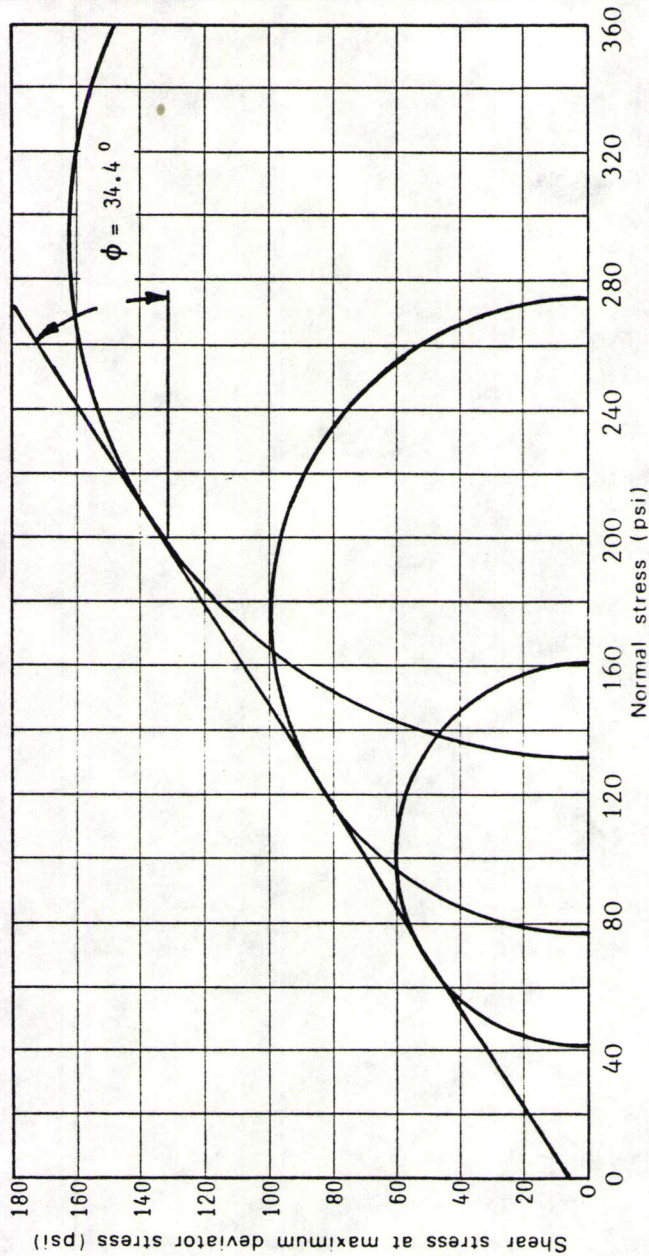
Figure no. _____ Boring no. HA-5
Surface elev. _____ Depth interval 22-24'
Moisture content 18.5 % Dry unit wt. 113.3 lbs/ft³
LL 21.0 % PL 16.5 % PI 4.5 %
Project Chevron Phosphate Facilities
Vernal, Utah

Time Consolidation Test
Sample HA-5, 22-24 feet

<u>Elapsed Time, min.</u>	<u>Dial Reading</u>		
	<u>0.58 tsf</u>	<u>1.15 tsf</u>	<u>2.30 tsf</u>
0	.0908	.0941	.1024
.1	.0908	.0961	.1095
0.25	.0908	.0967	.1096
0.5	.0909	.0972	.1098
1	.0911	.0977	.1101
2	.0914	.0981	.1102
4	.0917	.0984	.1103
8	.0920	.0988	.1106
15	.0923	.0991	.1109
30	.0926	.0994	.1110
60	.0928	.0997	.1111
120	.0930	.1001	.1112
240	.0932	.1004	.1113
480	.0936	(444) .1009	.1114
1420	.0941	(1421) .1024	(1440) .1116

Time Consolidation Test
Sample HA-5, 22-24 feet

<u>Elapsed Time, min</u>	<u>Dial Reading</u>		
	<u>4.60 tsf</u>	<u>9.20 tsf</u>	<u>18.40 tsf</u>
0	.1116	.1282	.1393
.1	.1155	.1300	.1496
0.25	.1165	.1307	.1499
0.5	.1172	.1314	.1500
1	.1179	.1320	.1503
2	.1184	.1326	.1506
4	.1188	.1332	.1509
8	.1193	.1337	.1516
15	.1198	.1342	.1524
30	.1203	.1347	.1531
60	.1208	.1353	.1540
120	.1214	.1361	.1549
240	.1220	.1368	.1559
480	.1270	(509) .1378	.1570
1420	(1415) .1282	(1447) .1393	(1434) .1590



Test no. or symbol	Boring no. or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minute)
		Dry density (pcf)	Moisture content (%)				Friction angle ϕ (degrees)	Cohesion (c/psi)		
○	15'-16.5'	110.0	19.3	100	43.0	119.3	34.4	2.0	2.8/1.32	.0016
●	15'-16.5'	110.0	19.3	100	77.0	205.1	34.4	2.0	2.8/1.32	.0016
▲	22'-24'	114.5	20.2	100	134.9	364.1	34.4	2.0	2.8/1.32	.0016



ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

TRIAXIAL SHEAR TEST
Project: CHEVRON PHOSPHATE FACILITIES
Vernal, Utah

HOLE NO. HA-5
DEPTH: 15' - 24'

FIGURE NO.

Table No. 3

Triaxial Shear Test
HA-5, 15-16.5

Dry Unit Weight	110.0
Natural Moisture Content	19.3
Confining Pressure	50 psi

<u>Strain</u>	<u>Deviator Stress, psi</u>	<u>Pore Pressure psi</u>
0.0214	83.3	39.4
0.0428	97.1	37.9
0.0643	105.1	38.3
0.0857	109.3	39.3
0.1071	110.5	39.4
0.1286	111.5	40.3
0.1500	114.0	40.9
0.1714	117.1	42.6
0.1929	118.9	42.8
0.2000	119.3	43.0

Table No. 4

Triaxial Shear Test
HA-5, 15-16.5 feet

Dry Unit Weight	110.0
Natural Moisture Content	19.3
Confining Pressure	100 psi

<u>Strain</u>	<u>Deviator Stress, psi</u>	<u>Pore Pressure psi</u>
0.0214	136.2	75.3
0.0428	163.5	69.3
0.0643	172.6	68.7
0.0857	183.4	71.0
0.1071	186.0	71.5
0.1286	189.2	72.8
0.1500	196.3	73.5
0.1714	205.1	77.0
0.1929	204.6	77.4
0.2000	204.7	77.5

Table No. 5

Triaxial Shear Test
HA-5, 22-24 feet.

Dry Unit Weight	114.5
Natural Moisture Content	20.2
Confining Pressure	150 psi

<u>Strain</u>	<u>Deviator Stress, psi</u>	<u>Pore Pressure, psi</u>
0.0214	218.6	116.8
0.0428	278.0	102.1
0.0643	306.2	105.1
0.0857	343.3	115.7
0.1071	354.7	122.2
0.1286	363.4	128.5
0.1500	365.4	131.5
0.1714	360.6	133.3
0.1929	364.1	134.6
0.2000	364.1	134.9

CHEVRON RESEARCH COMPANY
RICHMOND, CALIFORNIA

PETROGRAPHIC DESCRIPTION OF
VERNAL TAILINGS DAM WALL
ROCK CORES

Author - J. V. Heyse

HA 8 (Red Rock) Gypsum-
Cemented Coarse Siltstone

The rock consists of well-sorted quartz grains of approximately 50 microns in size abundantly cemented and veined by gypsum. The cement is stained red by fine-grained hematite and goethite. Trace constituents of the rock include: potassic feldspar, hematite, and rutile grains; dolomite cement; and chips of ferruginous mudstone.

HA 7 (White Rock) Gypsum

The rock consists of scattered 50-micron dolomite crystals in a very abundant groundmass of fibrous gypsum. Red layers in this rock consist of less gypsum and more dolomite plus some quartz grains and fine-grained hematite and goethite.

:dc



Engineering
and Testing, Inc.

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North Salt Lake City, Utah 84054
(801) 298-9314

TECHNICAL REPORT



Copy to IEC
Pat Griffin.

Report to:

Chevron Resources
Attn: Mr. Howard Abplanalp
Manila Star Route
Vernal, Utah 84078

Date: May 14, 1985

Job Number: 84-2320

Sheet: 1 of 1

Invoice No.: 21062

Report of: Laboratory Tests of Rock Core Samples

Sample Identification RED MOENKOPI SHALE FROM SOUTH BORROW AREA.

On May 1, 1985, we received at our laboratory two samples of rock core. At your request, we performed a specific gravity, absorption, and magnesium sulphate soundness tests in accordance with ASTM C97 and ASTM C88, respectively.

The test results are summarized as follows:

Test Results

	HA-8 17'-19' Lab No. 3443	HA-7 10.2'-12.2' Lab No. 3442
<u>Sieve Analysis - After Crushing</u>		
<u>Sieve Size</u>	<u>P E R C E N T</u>	<u>P A S S I N G</u>
3"	100	100
2"	95	82
1 1/2"	36	28
1"	14	10
3/4"	6	5
1/2"	4	3
3/8"	3	2
No. 4	2	1

Specific Gravity and Absorption

Bulk Specific Gravity, SSD	2.49	2.50
Absorption, %	3.0	0.7

Magnesium Sulphate Soundness

Percent Loss after 5 cycles	100	50
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Reviewed by

Curt Chute

This page is a reference page used to track documents internally for the Division of Oil, Gas and Mining

Mine Permit Number M0470007 Mine Name Vernal Phosphate
Operator SF Phosphate Co Date 10-28-1985
TO _____ FROM _____

☐ CONFIDENTIAL ☐ BOND CLOSURE ☐ LARGE MAPS ☒ EXPANDABLE
☐ MULTIPUL DOCUMENT TRACKING SHEET ☐ NEW APPROVED NOI
☐ AMENDMENT ☐ OTHER _____

Description

YEAR-Record Number

☐ NOI ☒ Incoming ☐ Outgoing ☐ Internal ☐ Superceded

Enlargement of Existing Tailings
Dam - Final Design Report

☐ NOI ☐ Incoming ☐ Outgoing ☐ Internal ☐ Superceded

☐ NOI ☐ Incoming ☐ Outgoing ☐ Internal ☐ Superceded

☐ NOI ☐ Incoming ☐ Outgoing ☐ Internal ☐ Superceded

☐ TEXT/ 8 1/2 X 11 MAP PAGES ☐ 11 X 17 MAPS ☐ LARGE MAP

COMMENTS: _____

CC: _____